# BRIDGEPORT
# SERIES I V2XT
# BRIDGEPORT DX-32 CONTROL

# INSTALLATION, MAINTENANCE, AND PARTS BREAKDOWN MANUAL

**Code No. 1104-1862**
**Rev. A**

**August 1996**

**IMPORTANT**

Before operation of this machine, the operator must read and complete the Operators Safety Test shipped with each machine. Operator Safety Manual code no. 11041128.

**IMPORTANT**

Bridgeport Machines, Inc. does not guarantee any interchange of Bridgeport parts or accessories on any other than Bridgeport Machines, i.e. any interchange of Bridgeport look alike.

**Changes:**

Chapter 4 (Power Distribution): includes latest wiring diagram.
Chapter 5 ·(Logic Boards): I/0 diagrams omitted.
Chapter 7 (Troubleshooting): included in this revision.
Chapter 8 (Tests): Information is included in Chapter 7. Chapter 8 is now Preventive Maintenance; subsequent chapters re-numbered accordingly.
Chapter 12 (Parts Breakdown):Updated electronic and mechanical drawings & part nos.

**© 1996 Bridgeport Machines, All Rights Reserved**

This manual provides information which is proprietary to Bridgeport Machines and is made available to you for the use and maintenance of our products. Any use, reproduction, or dissemination of this information for any other purpose without written permission is prohibited.

# IMPORTANT SAFETY NOTICE

Bridgeport Machines Inc. supplies a safety shield for protection from chips and coolant with every machine we ship.

The Bridgeport chip and coolant shields have been designed with the highest clear impact material commercially available: KODAR PETG Copolyester 6763. It has an impact strength 5 to 10 times greater than acrylic (plexiglass) or Butyrate (UVEX) materials, thereby offering the greatest protection for our customers.

Some of the new "easy to dispose of" coolant and/or cutting oils may contain chemicals harmful to Copolyester 6763. These chemicals are: Mono-Ethanolamine, Di-Ethanolamine, Tri-Ethanolamine and the combination thereof. **THESE CHEMICALS MAY SIGNIFICANTLY REDUCE THE IMPACT STRENGTH OF THE SHIELD.**

**USE OF COOLANTS AND/OR CUTTING OILS CONTAINING THESE CHEMICALS WILL VOID THE WARRANTY ON YOUR BRIDGEPORT SHIELD.**

# IMPORTANT SAFETY NOTICE
# WARNING

It is the user's responsibility to be acquainted with the legal obligations and requirements in the use and application of the machine particularly as discussed in the American National Standards Institute Standard Entitled Safety Requirements for the Construction, Care, and Use of Drilling, Milling, and Boring Machines.

## The Bridgeport Milling Machine

**SAFEGUARD INSTALLATION**

The Bridgeport Milling Machine is fitted with a chip and coolant shield spindle guard as standard. In certain cases and tooling applications additional guarding may have to be provided by the user.

The guards are made with clear plastic having high impact resistance to provide operator safety and a clear, unobstructed view of the operations in progress. The opening of any guard door provides access to potential hazard areas. Opening the guard doors will not stop the spindle. Extreme care must therefore be used at all times.

**SOFTWARE**

Any unauthorized changing of control parameters is not permitted. Bridgeport Machines will not accept any liability whatsoever for the alteration of any set parameters to those programmed at installation.

**AUTHORIZED PERSONNEL AND TRAINING**

Operating, service and maintenance engineers shall be authorized by the 'User Company' and properly trained in the use of the machine.

**SAFE WORKING PRACTICES**

Work holding devices, cranes, tooling, and their use shall be the responsibility of the user. It is the user's responsibility to protect against the hazards caused by chips, leaking oil or coolant and their use.

Use of proprietary oil or coolant is the responsibility of the user. Special instructions from the suppliers concerning their use should be carefully read and understood before use.

To prevent bodily injury, safe working practices should be employed when operating or servicing the machine.

# IMPORTANT

## SAFETY INFORMATION

To prevent bodily injury, you should observe the following basic safety precautions when installing, operating or servicing your Bridgeport milling machine.

1. Follow all instructions in the manual.
2. Wear approved industrial safety glasses and safety shoes.
3. **DO NOT** wear gloves, long sleeves, long hair, rings, watches, jewelry or other items that could become caught in moving parts.
4. Keep all parts of your body away from moving parts (belts, cutters, gears, etc.).
5. Use proper point-of-operation safeguarding.

These and other safety precautions are discussed in the American National Standards Institute Standard entitled *Safety Requirements for the Construction, Care, and Use of Drilling, Milling, and Boring Machines* (ANSI B11.8-1983).

This publication is available from: The American National Standards Institute
1430 Broadway
New York, NY 10018

Safeguarding for protection at the point of operation can only be designed and constructed when the parameters of the particular operation have been determined. As a result, ANSI B11.8-1983, Section 5.1, states that *"it shall be the responsibility of the employer to provide, and ensure the use of, a guard, guarding device, awareness barrier, awareness device, or shield..."*

To assist the machine users in designing point-of-operation safeguarding for their specific machine applications, the Occupational Safety and Health Administration has published a booklet entitled *Concepts and Techniques of Machine Safeguarding* (O.S.H.A. Publication Number 3067).

This publication is available from: The Publications Office - O.S.H.A.
U.S. Department of Labor
200 Constitution Avenue, NW
Washington, DC 20210

The general purpose point-of-operation shield provided with this machine may not be appropriate and cannot be utilized for all possible applications of the machine. Use additional or alternate safeguarding where this shield is not appropriate or cannot be utilized. Note that for purposes of this display, the shield has been removed in certain illustrations in this manual.

# BRIDGEPORT SAFETY LIST
# ALL COUNTRIES

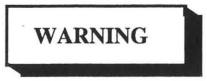
1. **DON'T** run your machine until you have read and understood the Bridgeport Operator and Maintenance manuals.
2. **DON'T** run your machine until you have read and understood all machine and control key signs.
3. **DON'T** run your machine for the first time without a qualified instructor. **ASK** your supervisor for help when you need it.
4. **PROTECT** your eyes. Wear safety glasses with side shields at all times.
5. **DON'T** get caught in moving parts. Remove watches, rings, jewelry, neck-ties, and loose-fitting clothes.
6. **PROTECT** your head. Wear a safety helmet when working near overhead hazards.
7. **KEEP** your hair away from moving parts.
8. **PROTECT** your feet. Always wear safety shoes with steel toes and oil-resistant soles.
9. Gloves are easily caught in moving parts. **TAKE THEM OFF** before you turn on the machine.
10. **REMOVE** all loose items (wrenches, chuck keys, rags, etc.) from machine before starting. Loose objects can become flying particles.
11. **NEVER** operate a machine tool after taking strong medication, using non-prescription drugs or consuming alcoholic beverages.
12. **SAFEGUARD** the cutting zone ("point of operation"). Use standard, general purpose safeguard where possible. Use special safeguards when required.
13. Protect your hands. **STOP** the spindle completely **BEFORE** changing tools.
14. Protect your hands. **STOP** the spindle completely **BEFORE** you load or unload a workpiece.
15. Protect your hands. **STOP** the spindle completely **BEFORE** you clear away chips or oil. Use brush or chip scraper. **NEVER** use you hands.
16. Protect you hands. **STOP** the spindle completely **BEFORE** you adjust the workpiece, fixture, or coolant nozzle.
17. Protect your hands. **STOP** the spindle completely **BEFORE** you take measurements.
18. Protect your hands. **STOP** the spindle completely **BEFORE** you open safeguard or covers.
19. Never reach around a safeguard.
20. Protect your hands. **STOP** the machine **BEFORE** you change or adjust belts, pulleys or gears.
21. **PROTECT** your hands. Keep hands and arms clear of spindle start switch when changing tools.
22. **PROTECT** your eyes and the machine. **NEVER USE A COMPRESSED AIR HOSE TO REMOVE CHIPS.**
23. **KEEP** work area well-lighted. Ask for additional light if needed.
24. **DON'T** slip. Keep your work area clean and dry. Remove chips, oil and obstacles.

25. **NEVER** lean on your machine. Stand away when the machine is running.
26. **DON'T** get trapped. Avoid pinch points caused by motion of table and head.
27. **PREVENT** objects from flying loose. Securely clamp and locate workpiece. Use stop blocks where necessary. **KEEP** clamps clear of cutter path.
28. **PREVENT** cutter breakage. Use correct table feed and spindle speed for the job. Reduce feed and speed if you notice unusual noise or vibration.
29. **PREVENT** cutter breakage. Rotate spindle in clockwise direction for right-hand tools, counterclockwise for left-hand tools. Use the correct tool for the job.
30. **PREVENT** workpiece and cutter damage. Never start the machine when the cutter is in contact with the workpiece.
31. **KEEP** tools sharp. Dull and damaged tools break easily. Inspect tools and tool holders. Keep tool overhang short.
32. **KEEP** rotating cranks and handwheels well-lubricated and maintained.
33. Certain materials, such as magnesium, are highly flammable in dust and chip form. See your supervisor before working with these materials.
34. **PREVENT** fire. Keep flammable liquids and materials away from work area and hot chips.
35. **PREVENT** machine table from moving unexpectedly. Disengage power feed when not being used (manual machines only).
36. **PREVENT** machine from moving unexpectedly. Always start machine in manual mode.

**WARNING**

**ANY UNAUTHORIZED CHANGING OF CONTROL PARAMETERS IS NOT PERMITTED. BRIDGEPORT MACHINES WILL NOT ACCEPT ANY LIABILITY WHATSOEVER FOR THE ALTERATION OF ANY SET PARAMETERS TO THOSE PROGRAMMED AT INSTALLATION.**

Danger notices are used in the publication to emphasize that lethal electrical voltages are present which could cause serious personal injury or death.




Warning notices are used in this publication to emphasize that hazardous mechanical conditions, voltages, currents, or temperatures exist in this equipment which could cause serious personal injury and/or damage to the equipment.

Caution notices are used where equipment might be damaged if care is not taken.

In situations where inattention could cause either personal injury or damage to the equipment, a WARNING notice is used.

## NOTE

Notes merely call attention to information that is especially significant in understanding and operating the equipment.

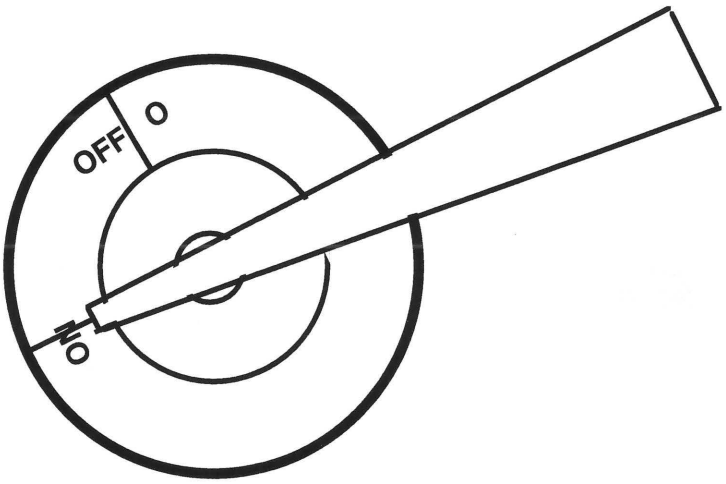
**IMPORTANT NOTICE**

DO NOT ATTEMPT DISASSEMBLY OR REMOVAL OF MAJOR COMPONENTS WITHOUT FIRST CONTACTING THE BRIDGEPORT MACHINES SERVICE DEPARTMENT FOR PROPER PROCEDURES.

This document is intended for the use of those who install, operate, and maintain the Bridgeport Milling Machine. Although reasonable care has been exercised in the preparation of this manual to make it complete and accurate, this manual does not purport to cover all conceivable problems or applications pertaining to this machine.

# ATTENTION

IMPORTANT SAFETY NOTICES




## MAIN DISCONNECT

DANGER

**HIGH VOLTAGE** is present in equipment control cabinet.

**DO NOT SERVICE** this cabinet before switching **MAIN DISCONNECT** to **OFF POSITION** and **DISCONNECTING POWER** at bus source.

# Table of Contents


| Chapter | | | Page |
|---|---|---|---|
| | SAFETY INFORMATION | | I-VI |
| 1 | **INTRODUCTION** | | |
| | 1.1 | PURPOSE AND SCOPE | 1-1 |
| | 1.2 | ORGANIZATION OF MATERIAL | 1-2 |
| | 1.3 | REFERENCE MANUALS | 1-2 |
| 2 | **INSTALLATION** | | |
| | 2.1 | UNCRATING | 2-1 |
| | 2.2 | SHORTAGES | 2-1 |
| | 2.3 | LIFTING THE MACHINE | 2-1 |
| | 2.4 | PREPARATION OF THE MACHINE LOCATION | 2-2 |
| | | 2.4.1 Foundation and Clearances | 2-2 |
| | | 2.4.2 Electrical Service | 2-3 |
| | | 2.4.3 Pneumatic Service | 2-3 |
| | 2.5 | PREPARATION FOR OPERATION | |
| | | 2.5.1 Removal of Shipping Blocks | 2-4 |
| | | 2.5.2 Cleaning the Machine | 2-4 |
| | | 2.5.3 Leveling the Machine | 2-5 |
| | | 2.5.4 Auxiliaries | 2-5 |
| | | 2.5.5 Spindle Trammeling | 2-6 |
| | | 2.5.6 Inspection of Electrical Enclosure | 2-6 |
| | 2.6 | SYSTEM POWER-UP AND INITIALIZATION PROCEDURES | 2-6 |
| | | 2.6.1 Prestart Considerations | 2-6 |
| | | 2.6.2 System Start-Up Procedure | 2-7 |
| | | 2.6.3 Power Phasing | 2-7 |
| | | 2.6.4 Start-Up Sheet | 2-7 |
| 3 | **MACHINE COMPONENTS AND SYSTEMS** | | |
| | 3.1 | SERIES I V2XT MACHINE | 3-1 |
| | | 3.1.1 Base Assembly | 3-1 |
| | | 3.1.2 Knee Drive | 3-2 |
| | | 3.1.3 Gib Adjustment | 3-2 |
| | | 3.1.4 The Milling, Drilling, and Boring Head | 3-2 |
| | | 3.1.5 Z-Axis Drive | 3-4 |
| | | 3.1.6 The Quill and Spindle | 3-4 |
| | 3.2 | THE CNC SYSTEM | 3-4 |
| | | 3.2.1 Operator Control System | 3-4 |
| | | 3.2.2 Central Processing Subsystem | 3-5 |
| | | 3.2.3 Power Subsystem | 3-5 |
| | | 3.2.4 Interface Subsystem | 3-5 |
| | 3.3 | AXIS DRIVES | 3-6 |
| | | 3.3.1 Axis Drive Subsystem | 3-6 |

# Table of Contents


| Chapter | | | Page |
|---|---|---|---|
| | 3.3.2 | Electro-Mechanical Subsystems | 3-6 |
| 3.4 | | MECHANICAL SUBSYSTEMS | 3-7 |
| 3.5 | | LUBRICATION SYSTEM | 3-7 |
| | 3.5.1 | Overview | 3-7 |
| | 3.5.2 | Way System Lubrication | 3-7 |
| 3.6 | | PNEUMATIC SYSTEM | 3-7 |
| | 3.6.1 | General Description | 3-7 |
| **4** | **POWER DISTRIBUTION** | | |
| 4.1 | | INTRODUCTION | 4-1 |
| 4.2 | | SYSTEM OVERVIEW | 4-1 |
| 4.3 | | SYSTEM PROTECTION | 4-1 |
| | 4.3.1 | Signal Ground | 4-1 |
| | 4.3.2 | Shielding | 4-1 |
| | 4.3.3 | Noise Suppression | 4-1 |
| 4.4 | | PROTECTIVE GROUND | 4-1 |
| 4.5 | | LINE VOLTAGE DISTRIBUTION BRANCH | 4-3 |
| | 4.5.1 | Spindle Motor Protection | 4-3 |
| 4.6 | | 115 VAC DISTRIBUTION BRANCH | 4-3 |
| | 4.6.1 | Lubrication Motor and System Fans | 4-3 |
| | 4.6.2 | SAFL Board | 4-3 |
| | 4.6.3 | The Duplex Receptacle | 4-3 |
| 4.7 | | 24 VOLT POWER SUPPLY | 4-4 |
| 4.8 | | 72 VAC DISTRIBUTION BRANCH | 4-4 |
| **5** | **LOGIC BOARDS** | | |
| 5.1 | | INTRODUCTION | 5-1 |
| 5.2 | | FRONT PANEL CONTROLS | 5-2 |
| 5.3 | | AUXBOB CARD | 5-3 |
| 5.4 | | MOTHER BOARD | 5-4 |
| 5.5 | | BMDC CARD | 5-4 |
| | 5.5.1 | BMDC Application Notes | 5-5 |
| | 5.5.2 | Diagnostic Software Features | 5-6 |
| | 5.5.3 | Quick Check for Proper BMDC Operations | 5-6 |
| | 5.5.4 | Status LEDs | 5-8 |
| | 5.5.5 | Function in System | 5-8 |
| 5.6 | | AXSBOB CARD | 5-8 |
| 5.7 | | AUF BOARD | 5-9 |
| | 5.7.1 | AUF Input Functions | 5-10 |
| | 5.7.2 | AUF Output Functions | 5-13 |

# Table of Contents


| Chapter | | | Page |
|---|---|---|---|
| 6 | **AXIS DRIVE SYSTEM** | | |
| | 6.1 | INTRODUCTION | 6-1 |
| | 6.2 | OVERVIEW | 6-1 |
| | 6.2 | MOTORS | 6-1 |
| | 6.4 | TRANSMISSION AND RESOLUTION | 6-1 |
| | 6.5 | POWER SUPPLY ASSEMBLY | 6-4 |
| | MOTION SCIENCE INC. USERS GUIDE | | 6-7 |
| 7 | **TROUBLESHOOTING** | | |
| | 7.1 | INTRODUCTION | 7-1 |
| | 7.2 | ELECTRICAL POWER TEST | 7-1 |
| | | 7.2.1 INCOMING POWER | 7-1 |
| | | 7.2.2 POWER SUPPLIES | 7-5 |
| | | 7.2.3 DX-32 POWER SYSTEM | 7-5 |
| | | DIAGNOSTICS AND PARAMETER FILES | 7-6 |
| | | PFM PROGRAM | 7-6 |
| | | PARAMETER EDITOR | 7-6 |
| | | READ ONLY PARAMETERS | 7-8 |
| | | LEADSCREW COMPENSATION | 7-8 |
| | | TUNER PROGRAM | 7-8 |
| | 7.3 | PARAMETER LIST | 7-13 |
| | 7.4 | ERROR MESSAGES | 7-22 |
| 8 | **PREVENTIVE MAINTENANCE** | | |
| | 8.1 | INTRODUCTION | 8-1 |
| | 8.2 | OVERVIEW | 8-1 |
| | 8.3 | EQUIPMENT AND SUPPLIES | 8-1 |
| | 8.4 | DESCRIPTION OF MAINTENANCE PROCEDURES | 8-1 |
| | 8.5 | OPERATOR MAINTENANCE REQUIREMENTS | 8-3 |
| | 8.6 | CLEANING PC CARDS | 8-3 |
| | 8.7 | AUXILIARIES SYSTEMS | 8-5 |
| 9 | **BASE ASSEMBLY** | | |
| | 9.1 | X AND Y-AXIS DRIVE MOTORS | 9-1 |
| | | 9.1.1 X-Axis Drive Motor Removal | 9-1 |
| | | 9.1.2 X-Axis Drive Belt Replacement | 9-2 |
| | | 9.1.3 Y-Axis Drive Motor Removal | 9-2 |
| | | 9.1.4 Y-Axis Drive Belt Replacement | 9-4 |
| | | 9.1.5 Y-Axis Drive Belt Adjustment | 9-4 |
| | 9.2 | X AND Y-AXIS BALLSCREWS | 9-5 |
| | | 9.2.1 X-Axis Ballscrew Removal | 9-5 |
| | | 9.2.2 X-Axis Vertical Ballscrew Inspection | 9-7 |
| | | 9.2.3 X-Axis Horizontal Ballscrew Inspection | 9-7 |

# Table of Contents


| Chapter | | | Page |
|---|---|---|---|
| | 9.2.4 | X-Axis Ballscrew Alignment | 9-7 |
| | 9.2.5 | Y-Axis Ballscrew Removal | 9-7 |
| | 9.2.6 | Y-Axis Ballscrew Inspection and Alignment | 9-9 |
| 9.3 | | LIMIT AND HOME SWITCH ADJUSTMENTS AND REPLACEMENT | 9-10 |
| | 9.3.1 | X-Axis Home and Overtravel Limit Switch Setting | 9-10 |
| | 9.3.2 | Synchronizing the X-Axis Motor | 9-11 |
| | 9.3.3 | Y-Axis Home Switch Setting | 9-11 |
| | 9.3.4 | Setting the Y-Axis Limit Switches | 9-13 |
| | 9.3.5 | Synchronizing the Y-Axis Motor | 9-13 |
| 9.4 | | TABLE AND SADDLE REMOVAL | 9-14 |
| | 9.4.1 | Table Removal | 9-14 |
| | 9.4.2 | Saddle Removal | 9-14 |
| 9.5 | | MANUALLY OPERATED KNEE | 9-15 |
| | 9.5.1 | Dial Replacement | 9-15 |
| | 9.5.2 | Crank Shaft Removal | 9-15 |
| | 9.5.3 | Knee Removal | 9-15 |
| | 9.5.4 | Knee Elevating Screw Replacement | 9-16 |
| 9.6 | | LUBRICATION | 9-16 |
| | 9.6.1 | X, Y, and Z-Axes | 9-16 |
| 9.7 | | ADJUSTMENT OF TABLE AND SADDLE GIBS | 9-17 |
| | 9.7.1 | Saddle to Table Gib Setting | 9-19 |
| | 9.7.2 | Saddle to Knee Gib Setting | 9-19 |
| | 9.7.3 | Knee to Column Gib Setting | 9-19 |
| 9.8 | | BACKLASH COMPENSATION ADJUSTMENT | 9-19 |
| | 9.8.1 | Introduction to FMDC Backlash | 9-19 |
| | 9.8.2 | Adjustment Using Software Compensation | 9-20 |
| | 9.8.3 | Entering Backlash Compensation Values | 9-20 |
| **10** | | **HEAD ASSEMBLY** | |
| 10.1 | | LUBRICATION | 10-1 |
| 10.2 | | PROGRAMMABLE SPINDLE SPEED | 10-1 |
| | 10.2.1 | Head Removal | 10-3 |
| | 10.2.2 | Motor Removal | 10-4 |
| | 10.2.3 | Vari-Drive Belt Replacement | 10-4 |
| | 10.2.4 | Timing Belt Replacement | 10-6 |
| 10.3 | | QUILL AND SPINDLE | 10-6 |
| | 10.3.1 | Spindle Locknut Assembly | 10-6 |
| | 10.3.2 | Spindle Removal | 10-7 |
| | 10.3.3 | Quill Drive Motor Replacement | 10-9 |
| | 10.3.4 | Quill Drive Belt Adjustment | 10-9 |
| | 10.3.5 | Quill Drive Belt Removal | 10-9 |
| | 10.3.6 | Ball Quill Assembly Removal | 10-10 |

# Table of Contents


| Chapter | | Page |
|---|---|---|
| | 10.3.7 Quill Removal | 10-12 |
| 10.4 | QUILL LIMIT AND DECELERATION SWITCH SETTING | 10-13 |
| | 10.4.1 Setting the Z-Axis Limit Switches | 10-13 |
| 10.5 | ALIGNMENT OF QUILL HOUSING TO DRIVE MOTOR HOUSING | 10-14 |
| 10.6 | BALL QUILL ASSEMBLY | 10-14 |
| | 10.6.1 Ball Quill Assembly Preload Torque on Nut | 10-15 |
| | 10.6.2 Cleaning and Flushing the Ball Quill Extension Assembly. | 10-15 |
| 10.7 | INSTALLATION OF PNEUMATIC BRAKE | 10-16 |
| 10.8 | PNEUMATIC SPEED CHANGER REPLACEMENT | 10-16 |
| **11** | **AUXILIARIES** | |
| 11.1 | INTRODUCTION | 11-1 |
| 11.2 | PNEUMATIC SYSTEM | 11-1 |
| | 11.2.1 Speed Changer and Brake | 11-1 |
| 11.3 | LUBRICATION SYSTEM | 11-1 |
| | 11.3.1 Overview | 11-1 |
| | 11.3.2 Maintenance and Service | 11-1 |
| | 11.3.3 Type TM-5 Lubricator Unit | 11-3 |
| | LUBE SPECIFICATION NO. 1-037-0001 | 11-5 |
| | LUBE SPECIFICATION NO. 1-037-0020 | 11-6 |
| 11.4 | PRESSURE REGULATOR | 11-7 |
| 11.5 | PRESSURE REGULATOR | 11-8 |
| 11.6 | MINIATURE MICRO-FOG LUBRICATOR | 11-10 |
| **12** | **PARTS BREAKDOWN** | |
| | MACHINE ASSEMBLY — FRONT VIEW | 12-1 |
| | MACHINE ASSEMBLY --- SIDE VIEW | 12-2 |
| | ELECTRICAL: | |
| | ELECTRICAL COMPONENT LAYOUT WITH CABLES | 12-4 |
| | CONTROL ENCLOSURE ASSEMBLY | 12-7 |
| | EQUIPMENT PANEL ASSEMBLY | 12-8 |
| | DOOR ASSEMBLY | 12-11 |
| | COMPUTER PANEL ASSEMBLY | 12-12 |
| | CARD CHASSIS | 12-15 |
| | HARD DISK DRIVE ASSEMBLY | 12-16 |
| | FLOPPY DRIVE ASSEMBLY | 12-19 |
| | 100V POWER SUPPLY ASSEMBLY | 12-20 |
| | 24V POWER SUPPLY ASSEMBLY | 12-23 |
| | LOGIC POWER SUPPLY | 12-24 |

# Table of Contents


| Chapter | Page |
|---|---|
| MOTOR ASSEMBLY | 12-27 |
| OPERATOR CONTROL ASSEMBLY | 12-28 |
| OPERATOR STATION CABLE | 12-31 |
| HORIZONTAL ARM ASSEMBLY | 12-32 |
| CRT HOUSING ASSEMBLY | 12-35 |
| MECHANICAL: | |
| BASE ASSEMBLY | 12-36 |
| HEAD ASSEMBLY | 12-44 |
| SPEED CHANGER ASSEMBLY | 12-51 |
| SPINDLE SPEED POT CABLE ASSEMBLY | 12-52 |
| LIMIT SWITCH GROUP | 12-55 |
| PNEUMATIC BRAKE ASSEMBLY | 12-56 |
| #30 Q.C. SPINDLE ASSEMBLY | 12-58 |
| #200 UNIVERSAL SPINDLE ASSEMBLY | 12-59 |
| AUXILIARIES SYSTEM | 12-61 |
| LUBE, MIST AND PNEUMATIC SYSTEM | 12-62 |
| WAY LUBRICATION TANK & PUMP ASSEMBLY | 12-63 |
| OPTIONAL EQUIPMENT: | |
| BASE AND FILTER ASSEMBLY | 12-64 |
| BASE PAN KIT | 12-64 |
| FLOOD COOLANT PUMP AND MOTOR | 12-65 |
| FLOOD COOLANT, NOZZLE/HEAD/1 HEAD (Tank on Front) | 12-66 |
| NOZZLE ASSEMBLIES (Flood and Mist) | 12-66 |
| MIST TANK ASSEMBLY | 12-67 |
| POWER DRAWBAR KIT | 12-68 |
| SPARE PARTS: | |
| POWER EQUIPMENT ASSEMBLY | 12-69 |
| DRIVE POWER SUPPLY ASSEMBLY | 12-69 |
| OPERATORS CONTROL PANEL ASSEMBLY | 12-69 |
| OPERATORS STATION ASSEMBLY | 12-69 |
| BASE ASSEMBLY | 12-69 |
| HEAD ASSEMBLY | 12-69 |
| PNEUMATIC SPEED CHANGER | 12-69 |
| WAY LUBRICATION TANK AND PUMP ASSEMBLY | 12-69 |
| INDEX CONTROL KIT | 12-69 |
| BASE PAN KIT | 12-69 |

# Table of Contents


| Chapter | | Page |
|---|---|---|
| **APPENDIX A - SYSTEM SPECIFICATIONS** | | |
| A-1 | OVERVIEW | A-1 |
| A-2 | FEATURES OF THE SERIES I V2XT | A-1 |
| A-3 | BRIDGEPORT DX-32 CONTROL SPECIFICATIONS | A-2 |
| A-4 | MACHINE SPECIFICATIONS | A-6 |
| **APPENDIX B - STATIC SENSITIVE EQUIPMENT** | | |
| B.1 | STATIC SENSITIVE MATERIALS | B-1 |
| B.2 | GENERAL GUIDELINES | B-1 |
| B.2.1 | Equipment Required | B-1 |
| B.2.2 | Procedure | B-1 |
| B.3 | VENDOR INFORMATION FOR STATIC PROTECTION EQUIPMENT | B-1 |


## List of Illustrations


| Figure | | Page |
|---|---|---|
| 1-1 | Series I V2XT | 1-1 |
| 2-1 | Overall Dimensions | 2-1 |
| 2-2 | Side Elevation | 2-2 |
| 2-3 | Machine Base Layout | 2-3 |
| 2-4 | Installation Plan View | 2-3 |
| 2-5 | Overhead Hoist | 2-4 |
| 2-6 | Center of Gravity | 2-4 |
| 2-7 | Machine Leveling | 2-5 |
| 2-6 | X and Y-Axis Head Trammeling | 2-5 |
| 3-1 | Series I V2XT | 3-2 |
| 3-2 | Knee Drive Transmission | 3-2 |
| 3-3 | Spindle Drive Transmission | 3-2 |
| 3-4 | Milling, Drilling, and Boring Head | 3-3 |
| 3-5 | V2XT System - Function Blocks | 3-4 |
| 3-6 | CRT & Front Panel Controls | 3-5 |
| 3-7 | Auxiliaries Assembly | 3-6 |
| 4-1 | Power Distribution | 4-2 |
| 4-2 | Typical Graphic Symbols for Electronic Diagrams | 4-6 |
| 5-1 | System Block Diagram | 5-1 |
| 5-2 | CRT & Front Panel Controls | 5-2 |
| 5-3 | Emergency Stop Circuit | 5-11 |
| 6-1 | Axis Drive - Functional Blocks | 6-1 |
| 6-2 | DC Servo Motors | 6-2 |
| 6-3 | X and Y-Axis Drive Transmission | 6-2 |

# Table of Contents


| Figure | | Page |
|---|---|---|
| 6-4 | X-Axis Limit Switch Locations | 6-3 |
| 6-5 | Y-Axis Limit Switch Locations | 6-3 |
| 6-6 | Z-Axis Drive | 6-3 |
| Motion Science User Guide: | | |
| | 1 Servo System Diagram | 6-12 |
| | 2 Trapezoidal Velocity Profile | 6-14 |
| | 3 HB Amplifier P.C. Board Layout | 6-16 |
| | 4 Logic Connector Interface Schematic | 6-20 |
| | 5 Power Supply Circuit | 6-21 |
| | 6 Current Limit Adjustment Graph | 6-25 |
| 7-2 | Troubleshooting Flowchat | 7-2 |
| 9-1 | X-Axis Drive Assembly | 9-1 |
| 9-2 | Y-Axis Drive Assembly | 9-2 |
| 9-3 | Base Assembly (Front View) | 9-3 |
| 9-4 | X-Axis Vertical Ballscrew Inspection | 9-4 |
| 9-5 | Y-Axis Vertical Ballscrew Inspection | 9-5 |
| 9-6 | X-Axis Ballscrew Alignment | 9-6 |
| 9-7 | Base Assembly (Side View) | 9-6 |
| 9-8 | Y-Axis Ballscrew Inspection | 9-9 |
| 9-9 | X-Axis Limit Switch | 9-10 |
| 9-10 | Y-Axis Limit Switch | 9-12 |
| 9-11 | Manual Knee Drive | 9-15 |
| 9-12 | Gib Locations | 9-17 |
| 9-13 | Gib Adjustments | 9-18 |
| 10-1 | Setting Speed Control | 10-1 |
| 10-2 | Special Tool ST-6921 Headlift Bracket | 10-2 |
| 10-3 | Head Removal | 10-2 |
| 10-4 | Motor Removal | 10-3 |
| 10-5 | Vari-Drive and Timing Belt | 10-5 |
| 10-6 | Quick Change Locknut Assembly | 10-7 |
| 10-7 | Spindle Removal | 10-7 |
| 10-8 | Quill Drive | 10-8 |
| 10-9 | Ball Quill | 10-11 |
| 10-10 | Limit Switches | 10-12 |
| 10-11 | Ball Quill Extension Torque on Nut Setup | 10-14 |
| 10-12 | Ball Quill Extension Flushing | 10-15 |
| 10-13 | Ball Quill and Nut Flushing | 10-16 |
| 10-14 | Pneumatic Brake | 10-17 |
| 10-15 | Pneumatic Speed Changer Replacement | 10-18 |

# Table of Contents

## List of Tables


| Table | | Page |
|---|---|---|
| 4-1 | Overload Heaters | 4-3 |
| 4-2 | Fuse Chart | 4-7 |
| 7-1 | Axis Preventive Maintenance Procedures | 7-3 |
| 7-2 | Axis Troubleshooting Chart | 7-3 |
| 9-1 | Operators Maintenance Requirements - Regular Shift | 9-4 |
| 9-2 | Operators Maintenance Requirements - Multiple Shift | 9-5 |

# CHAPTER 1. Introduction

## 1.1 PURPOSE AND SCOPE

This manual contains the information needed to install, maintain, troubleshoot and repair the V2XT Milling, Drilling, and Boring machine with the Bridgeport DX-32 Control. The information presented covers all tasks and levels of skills needed for the maintenance of a computer controlled milling machine. This manual includes theory of operation, preventive maintenance, troubleshooting, adjustments, and parts replacement. Attendance at Bridgeport Service Training School is recommended.

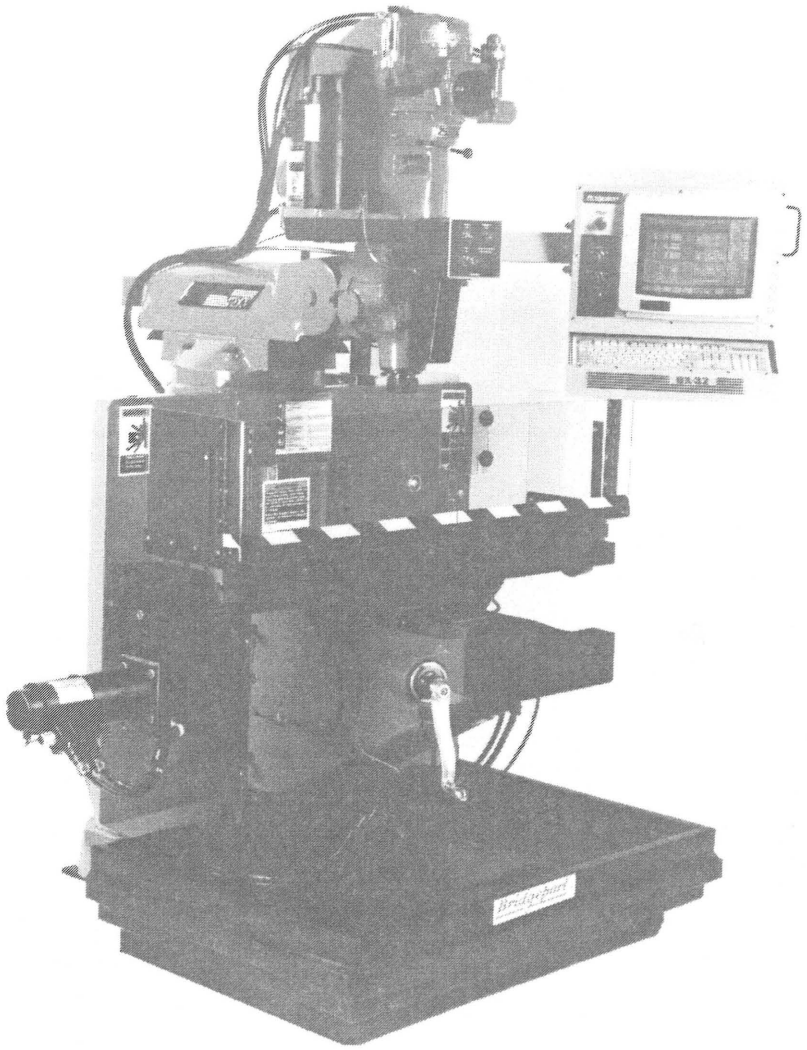


**Figure 1-1.** Series I V2XT

# 1. Introduction

## 1.2 ORGANIZATION OF MATERIAL

This manual has been divided into chapters to make information easy to find. Each chapter has a topic and contains all the information on that topic.

**Chapter 2: Installation**:
Provides lifting, foundation preparation, lubrication, and initial setting of machine.

**Chapters 3, 4, 5, and 6: Systems:**
Provides a description of the DX controls and its theory of operation. Chapter 3 covers Machine Components and Systems. Chapter 4 covers Power Distribution, Chapter 5 covers Logic Boards, and Chapter 6 covers Axis Drive System. This is done so that all maintenance personnel can fully understand the information needed for their level of maintenance.

**Chapters 7, and 8: Maintenance:**
Chapter 7 covers Troubleshooting and Tests for the controls system, Chapter 8 covers Preventive Maintenance.

**Chapters 9 and 10: Base and Head Assemblies:**
Cover parts replacements and adjustments for the milling machine.

**Chapter 11: Auxiliaries:**
Details the auxiliary systems used on the machine.

**Chapter 12: Parts Breakdown:**
Covers the parts breakdown for the machine and equipment.

**Appendix A - System Specifications.**
Provides features of the V2XT Milling Machine.

**Appendix B - Static Sensitive Equipment:**
Contains information on the safe handling of static-sensitive materials.

## 1.3 REFERENCE MANUALS

Other manuals that deal with the V2XT Milling Machine:

Code No. 1104-1860 — Operating Manual
Code No. 1104-2638 — Programming Manual

# CHAPTER 2. Installation

## 2.1 UNCRATING

Carefully remove crating so that the machine and parts are not marred, scratched or impaired. In the event of damage in transit, communicate **AT ONCE** with our representative and the transportation company making delivery.

## 2.2 SHORTAGES

Check shipment carefully, against the itemized packing list which is included in the parts box. In case of shortages, report them **IMMEDIATELY** to the representative from whom the machine was purchased, indicating parts not received which have been checked on the packing list.

## 2.3 LIFTING THE MACHINE (Figure 2-1, 2-2)

Keep the machine on its skids until it has reached its installation position. The following procedure is for removing it from its skid and placing it in position, not for transporting it.

**WARNING**

Be sure that all lifting and rigging equipment is in good working order and adequately rated for its job. Failure to do so will cause personal injury or equipment damage.

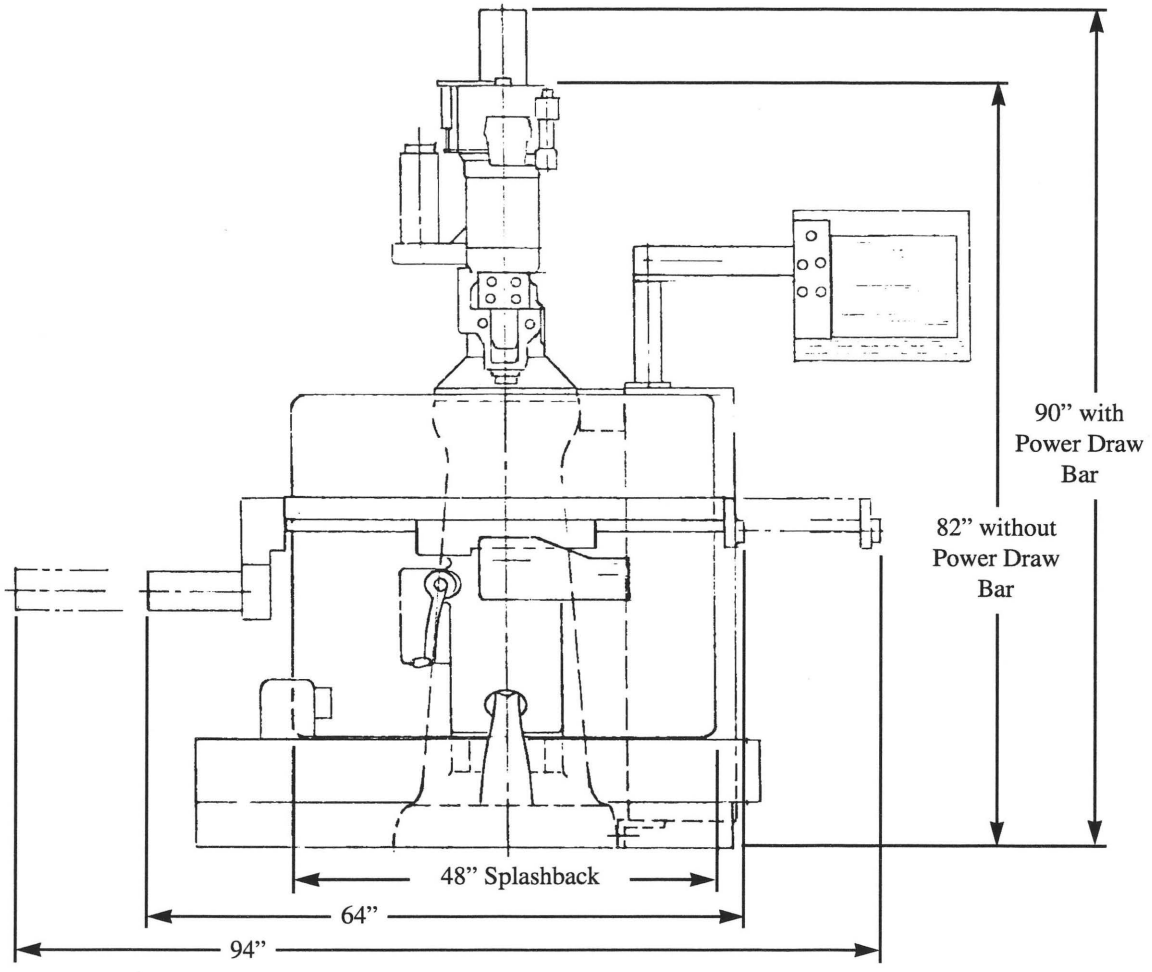



**Figure 2-1.** Overall Dimensions

# 2. Installation

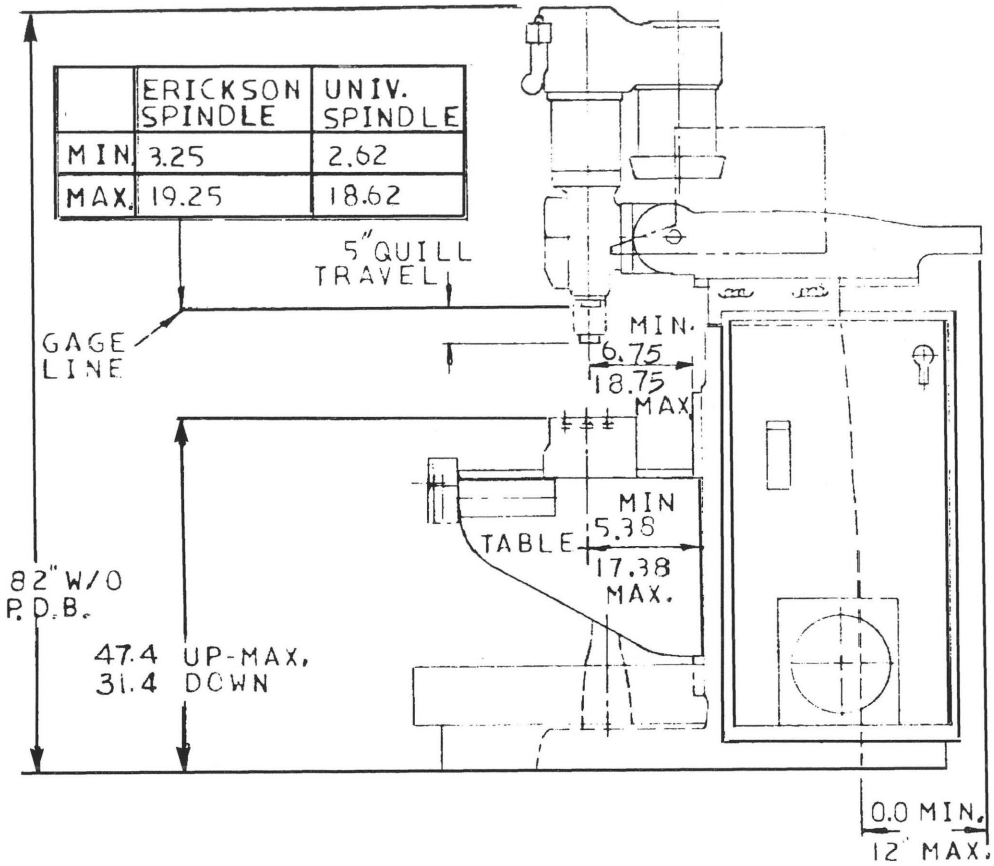



**Figure 2-2.** Side Elevation

1. Remove the four bolts securing the machine base to the skid.

   **NOTE**

   Gross weight of the V2XT machine is 3150 lbs.

2. Secure the ram properly before lifting the machine. The four bolts which secure the ram to the column should be torqued to 47 ft. lbs. (Figure 2-5).
3. Tighten ram locking bolts before lifting the machine.
4. Fasten a proper sling of adequate capacity under the front portion of the ram and the back of the ram.
5. Lift the machine with a forklift or an overhead crane of adequate capacity. If using a forklift, place the fork through the sling to lift. If using an overhead crane, place a lifting hook through the sling to lift, then gently set it in place. Center of gravity is indicated in Figure 2-6.

## 2.4 PREPARATION OF THE MACHINE LOCATION

### 2.4.1 Foundation and Clearances

The column and base are cast in one piece. When setting the machine on a prepared foundation of concrete (optional) or on the shop floor, use shim plates, adjustable mounting pads, or thin grouting to compensate for unevenness in the floor.

It is an OSHA requirement that the machine be bolted to the floor. Figure 2-3 shows the base dimensions and the 21/32 in. diameter clearance holes for 5/8 in. bolts.

# 2. Installation

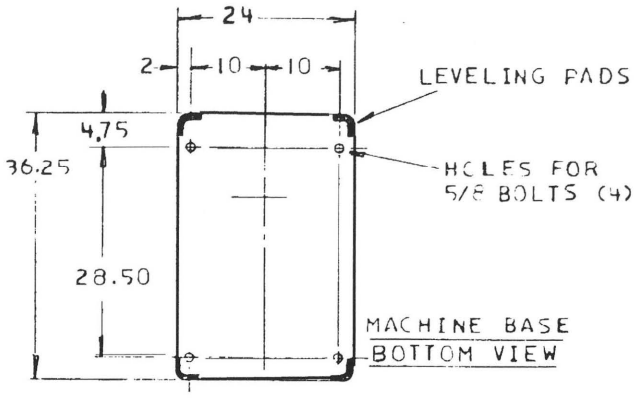



**Figure 2-3.** Machine Base Layout

Figure 2-6 shows the necessary clearance around the machine for access door opening and maintenance. Use these clearances for the remainder of the installation.

### 2.4.2 Electrical Service

The machine is wired for a specific voltage frequency and fused accordingly. Check the label on the outside of the Power Equipment Enclosure door to determine the exact compatibility with your electrical service.

The electrical service entry is at the top of the Power Equipment Enclosure where a 1-1/8 in. diameter hole has been provided for electrical conduit fitting.

All service requirements are indicated in figure 2-4.

**WARNING**

Machine must be hooked up by a qualified electrician.

### 2.4.3 Pneumatic Service

80 psi required for 1/2 NPT connection, 20 feet is supplied.

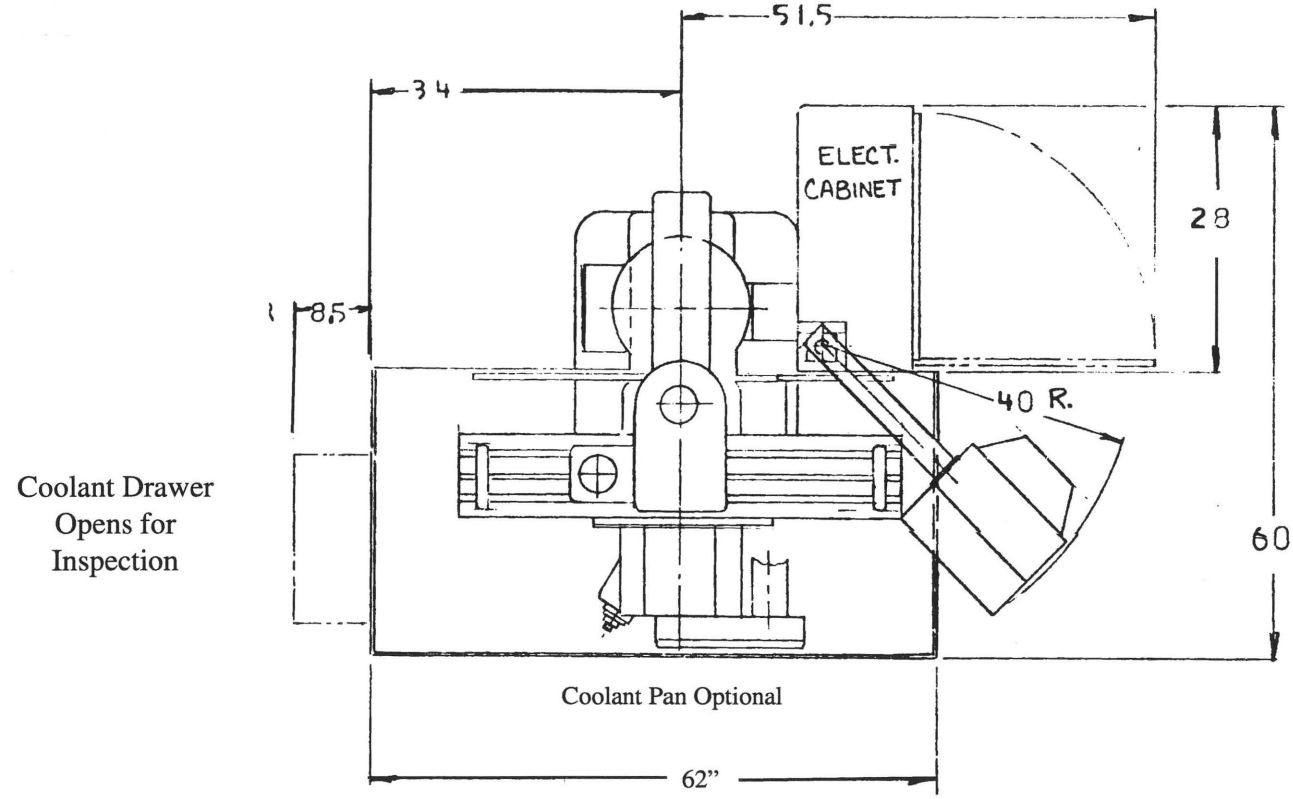



**Figure 2-4.** Installation Plan View

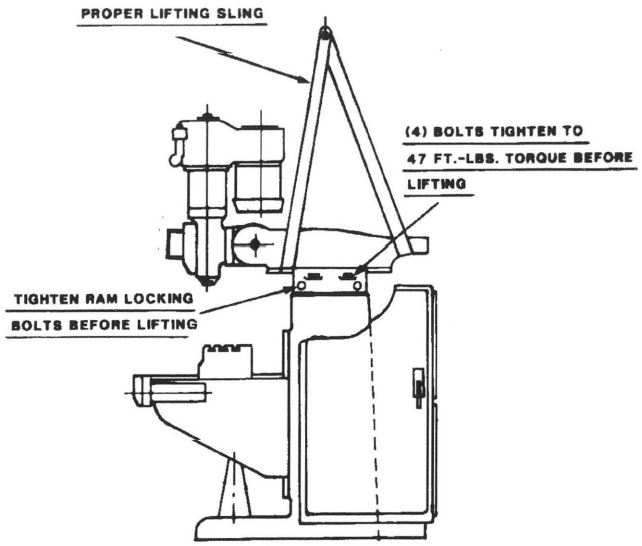



**Figure 2-5.** Overhead Hoist

## 2.5 PREPARATION FOR OPERATION

### 2.5.1 Removal of Shipping Blocks.

Perform the following steps to set up the machine.

1. Remove the pendent arm restraint.
2. Raise the knee and remove the knee brace
3. Lower the knee to the lowest point; make sure there is no interference.

### 2.5.2 Cleaning the Machine

After final acceptance testing at the factory, the machine is spray painted and treated with cosmoline rust preventative. Clean all rust preventative from machine with kerosene.

**WARNING**

Do not use gasoline, chlorinated hydrocarbons or similar flammable or toxic cleaning agents...These materials can cause fire and result in serious personal injury.

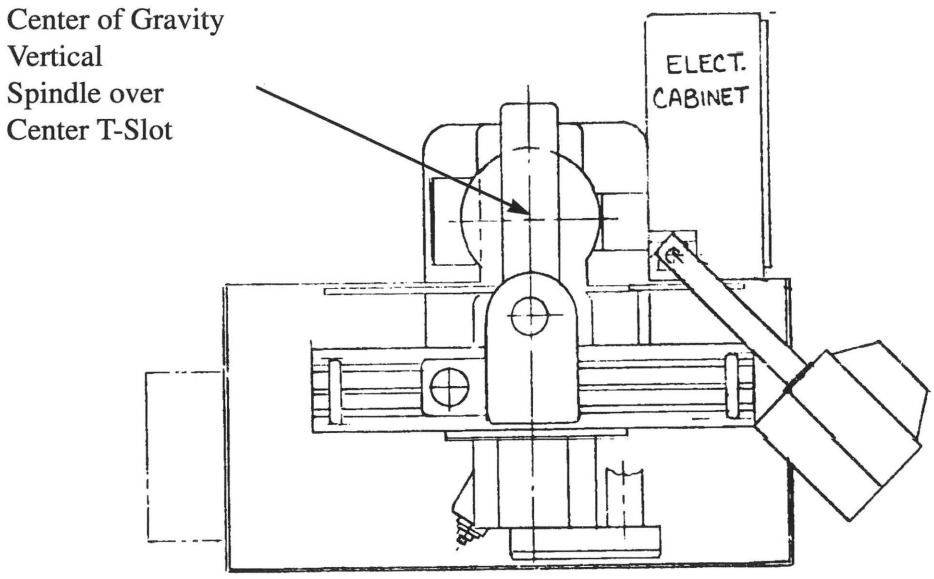



**Figure 2-6.** Center of Gravity

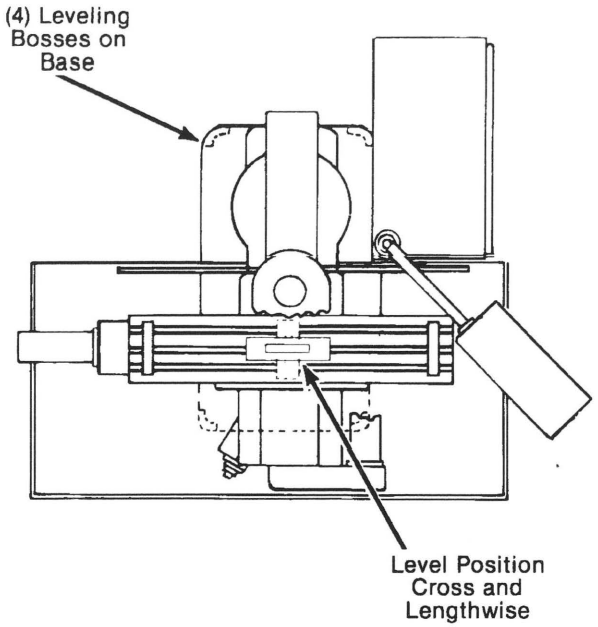



**Figure 2-7.** Machine Leveling

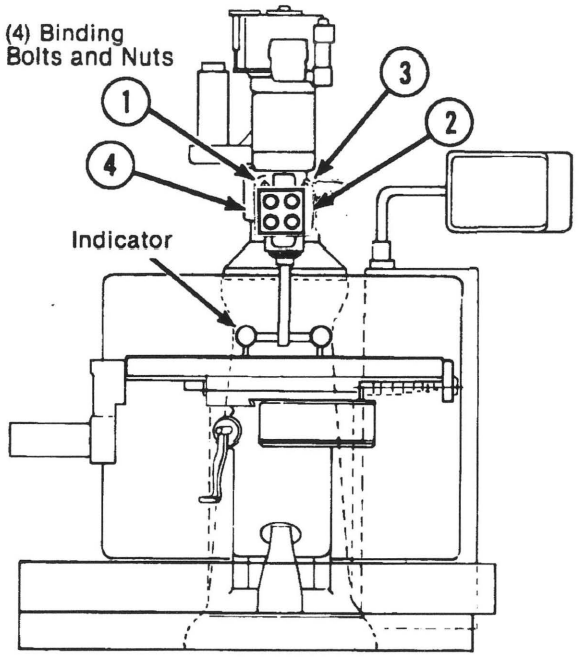
Clean and lubricate all exposed sections of the table, saddle, and knee ways. Cleaning may also include scraping paint from some of the hidden surfaces where masking may not have been completely effective.

### 2.5.3 Leveling the Machine

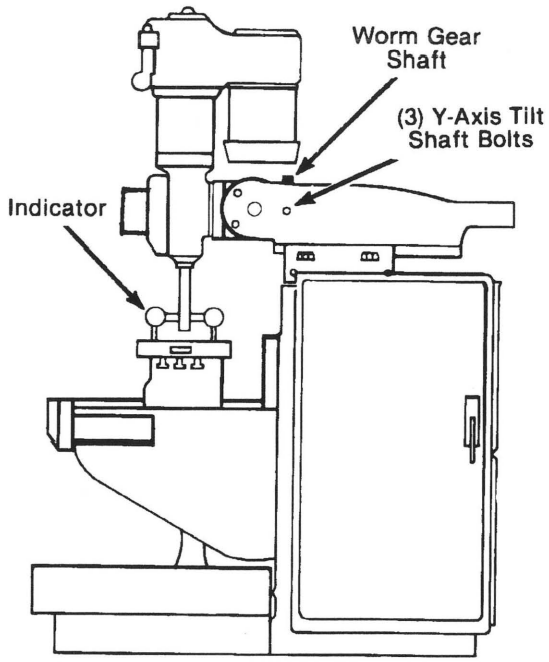
After locating the machine on its foundation (optional), level it in two directions and retain with hold down bolts as required by OSHA. Figure 2-7 shows a precision level on the top surface of the table. Adjust by placing shims under the four corner pads under the base. Repeat the procedure horizontally and vertically until level, then secure the machine to its foundation.

### 2.5.4 Auxiliaries

The lubrication system and operator's duties are detailed in Chapter 11. Duties and operation of the pneumatic system are also detailed in Chapter 11.




Note:
Tighten the (4) Binding Bolts and Nuts, in the Numbered Sequence, to 25 ft./lbs. Torque. Then Repeat and Tighten, in the Numbered Sequence, to 50 ft./lbs. Torque.




Note:
Tighten the (3) Binding Bolts to 50 ft./lbs. Torque.

**Figure 2-8.** X and Y-Axis Head Trammeling

### 2.5.5 Spindle Trammeling

The spindle has been properly trammeled at the factory. It is recommended that the setting of the head is checked to ensure that it has not moved during shipment.

**Set-Up** The head alignment should be made with the table X and Y-axis at mid-travel. Center the head over the table with the center T slot in the table.

**X-Axis Head Tram** Mount a dial indicator in an end mill holder or collet chuck and place it in the spindle. Set the dial indicator to a radius of four inches. No adjustment is needed if the total indicator runout along the X-axis is within 0.0005 in. If adjustment is needed, loosen the four binding bolts (Figure 2-8). Leave a slight tension on these bolts to provide some drag. Rotate the worm gear shaft bolt to tilt the head and bring the X-axis total indicated runout within specifications. Tighten the four binding bolts as noted in Figure 2-8.

**Y-Axis Head Tram** With the dial indicator still mounted in the spindle, check to see that the total indicator runout along the Y-axis is within 0.0005 in. If adjustment is needed, loosen the three Y-axis tilt shaft bolts and the worm gear shaft bolt shown in figure 2-8. After making the adjustments, torque the three Y-axis tilt shaft bolts to 50 ft. lbs.

### 2.5.6 Inspection of Electrical Enclosure

Lethal voltages are present in the power Equipment Enclosure, Turn Main Disconnect to OFF when working in power equipment enclosures. Failure to do so may result in serious injury or death.

1. The Power Equipment Enclosure is located at the right side of the machine with main power distribution located in the upper section.
2. Open the Power Equipment Enclosure door and check tightness of all screw-type terminal blocks, and the proper securing of all terminal wires.
3. Check printed circuit board connectors and terminal block wiring for tightness.
4. Check external cables for fraying or chafing which may have occurred during shipment. (If damage is found, report immediately to your Bridgeport dealer.)

## 2.6 SYSTEM POWER-UP AND INITIALIZATION PROCEDURES

Lethal voltages are present in the power Equipment Enclosure, Turn Main Disconnect to OFF when working in power equipment enclosures. Failure to do so may result in serious injury or death.

The following procedures should be performed by qualified maintenance personnel using extreme caution.

### 2.6.1 Prestart Considerations

The following procedure is necessary for initialization of the V2XT system. Make certain that all set-up and prestart maintenance has been completed before attempting to start the machine. Make a careful check of the following conditions before applying power.

1. Level of lubricating oil—refill if low
2. Air pressure level—adjust to nominal 80 psi
3. Make sure way areas are cleared
4. Position X, Y, and Z-axes relative to the spindle
5. Perform instructions for section 1 of the Start-Up Sheet.

If problems occur with any of the prestart checks, do not start the machine. Check the maintenance manual for proper start-up maintenance procedures. Failure to do so may result in machine damage.

### 2.6.2 System Start-Up Procedure

Before turning on the power disconnect, execute the electric tests 2.1, 2.2, and 2.3 in the start-up sheets for the Explorer I at the end of this chapter. Only after the above instructions have been completed can the disconnect be turned on and tests 2.4, 2.5, and 2.6 can be performed.

These tests must be made with the electrical disconnect closed and the enclosure door open. EXTREME CAUTION must be exercised to prevent harm due to electrical shock.

**NOTE**

The power must be turned off after each test is complete and turned on again to take the next reading.

Complete the remainder of start-up test. See steps 3.0 through 8.0.

To avoid damage to the machine, select the correct jog direction. Software travel limits are not active until after the next homing operation. The operator must determine which axis is on a limit or if the EMERGENCY STOP BUTTON is active.

### 2.6.3 Power Phasing

The spindle motor is the only part of the system affected by input power phasing. If the spindle rotates in the wrong direction, turn off the Main Disconnect switch, also disconnect incoming supply and interchange any two wires of the incoming 3-phase power.

| | | Speed/Range |
|---|---|---|
| **Control** | **Lever** | **Direction** |
| High | High | CW |
| Low | Low | CW |
| High | Low | CCW |
| Low | High | CCW |

### 2.6.4 Start-Up Sheet

Refer to the following system start-up sheet for instructions on system initialization and checkout. Follow each instruction in the order given for proper check out of machine. This procedure is intended for use by a qualified Level 3 Technician.

# START-UP SHEET FOR MACHINE

MACHINE S/N _____
CONTROL S/N _____
BOSS B/L _____
SALES/SERVICE CENTER/DISTRIBUTOR
_____
TESTED BY _____
DATE _____

CUSTOMER _____
ADDRESS _____
_____
_____
SERVICE REPORT NO. _____
INITIAL _____
WIRED FOR (Circle One) 208V 230V 480V

## 1.0 VISUAL INSPECTION

1.1 Check system nameplates for correct information. ____

1.2 Check for proper fuse labeling and sizes. ____

1.3 Insure tightness of all hardware and wire terminations. Insure that all cards and connectors are seated. ____

1.4 Check that T1, T2, overload heaters, REF. D1943101, and the spindle motor are wired for correct voltage.. ____

1.5 Check lube oil level. ____

1.6 Check air pressure. ____

1.7 Check air lubrication bowl. ____

## 2.0 ELECTRICAL TEST

2.1 Check for shorts between all power supply outputs and ground (ac, dc and power input lines) before applying power to the system. ____

2.2 Insure that the disconnect prevents the door from opening. ____

## 3.0 CONTROL START-UP

3.1 Install the color monitor and the front switch panel as one assembly. The monitor is installed from the front of the pendant box. ____

3.2 Connect the three cables necessary for the panel assembly. They are:

a. A brown twelve pin connector that connects the front switches to the control. ____

b. The power cable that connects the color monitor to the 115 vac. ____

c. The video cable to the color monitor. ____

3.3 Turn on the power disconnect. ____

3.4 The power will come up on the color monitor and print a message as it reads the software operating system from the hard disk. ____

3.5 After it has completed reading the disk, there is a pause of about 30 seconds as it goes through a diagnostic test of first, the software that has installed, and secondly the printed circuit boards. If the test fails, a message will appear on the CRT screen. ____

3.6 Refer to the operator's manual to enable the motor drives to home the machine. ____

## 5.0 BACKLASH COMPENSATION CHECK

**NOTE**

The backlash compensation was adjusted at the factory before the final acceptance cut was made.

5.1 Check and record the backlash offset on the X and Y-axis after the machine is installed. Refer to paragraph 9.8.2 of this manual for the backlash test procedure.

X-Axis ____
Y-Axis ____

**NOTE**

The machine should be well lubricated before making this test.

5.2 If the backlash is incorrect, install the correct number and record the new backlash offset Refer to paragraph 9.8.3 for instructions on inputting backlash compensation.

X-Axis ____
Y-Axis ____

**6.0 SPINDLE CONTROL CHECK**

6.1 In computer· ____

6.2 Select spindle on in high gear; spindle must come on, brake must go.off. Verify that spindle spins in the proper direction. Turn spindle off; spindle must go off, brake must come on. ____

6.3 Select low gear; spindle must come on, brake must go.off. Verify that spindle spins in the proper direction. Turn spindle off; spindle must go off, brake must come on. ____

6.4 Select spindle on in low gear;depress spindle increase;spindle speed must increase. Depress spindle decrease; spindle speed must decrease. Repeat for high gear. ____

**7.0 COOLANT CHECK**

7.1 Plug motor into coolant receptacle. Select flood coolant on. Motor must go on. Select flood coolant off; motor must go off. ____

7.2 Turn the coolant on and off ten (10) times consecutively. Verify that the system did not lock up. ____

7.3 Turn the coolant on. Turn the spindle off and verify that coolant goes off. Turn the spindle on and verify that the coolant goes on again. ____

7.2 Check mist coolant operation. ____

**8.0 FEEDRATE, ACCEL/DECEL, AND VECTOR VELOCITY CHECK**

8.1 Adjust the feedrate override potentiometer to 100%. Select a feedrate of 10 inches/min. Select an X-axis move of 10.0 inches. Time of move = 60 seconds plus or minus 3. ____

8.2 Select a feedrate of 10 ipm and a three axis move of 4.0 inches. Time of move = 42 seconds plus or minus 3. ____

***See Data Table, next page.***

**DATA TABLE**

| AC Line Input: | L1 | L2 | L3 |
|---|---|---|---|
| | | | (200-216) |
| | | | (220-240) |
| | | | (435-485) |
| Volts | ____ | ____ | ____ |
| Tl Secondary: | | | |
| Wire # (10-11) | (115 ± VAC) | | ____VAC |
| T2 Secondary: | | | |
| Wire # (2-4) | (115 ± VAC) | | ____VAC |
| Wire # (2-1) | (72 ± VAC) | | ____VAC |
| Wire # (23) | (72 ± VAC) | | ____VAC |
| Logic Supply | | | |
| (Measured on 486) | | | |
| +5V+ 0.05V | ____ | ____ | 100MV |
| +12V+ 0.5V | ____ | ____ | 100MV |
| -12V _ 0.5V | ____ | ____ | 100MV |
| | ____ | ____ | 100MV |
| AUF Regulator: | | | |
| +5V + 0.2V/ -0.lV | ____ | ____ | 1V |
| +24V ± 2V Wires 40 to 39 | | | |
| Drive Supply: | | | |
| +105V ± 5V | ____ | ____ | N/A |

AC LINE INPUT VOLTS

| PHASE TO PHASE | PHASE TO GROUND |
|---|---|
| Ll TO L2 ____ VAC | Ll TO GND ____ VAC |
| L2 TO L3 ____ VAC | L2 TO GND ____ VAC |
| L3 TO Ll ____ VAC | L3 TO GND ____ VAC |

Tl SECONDARY TERMINAL
(X7-X8) 115 VAC ± 11.5V ____ VAC

T2 SECONDARY TERMINAL

| | | |
|---|---|---|
| ( 9-12) | 115 VAC ± 11.5V | ____ VAC |
| (12-13) | 72 VAC ± 5V | ____ VAC |
| (10-12) | 72 VAC ± 5V | ____ VAC |

XT POWER SUPPLY
(Voltage check from spare disk drive plug)

| | | |
|---|---|---|
| RED-BLACK | +5VDC ± 0.250V | ____ VDC |
| YELLOW-BLK | +12VDC ± 1.2V | ____ VDC |

AUF CARD
JP12 (Wire #40 to #39) +24VDC + 3.6V/ -2.4V ____ VAC

100 VDC AXIS DRIVE SUPPLY
Wire # 50 to 2 100VDC ± 8 ____ VAC

BACKLASH
X-AXIS = ____
Y-AXIS = ____

SPINDLE RUN OUT
MAX 0.0002 ____

GIB SETTING
KNEE TO SADDLE =
POSITION #l = ____
POSITION #2 = ____

SADDLE TO TABLE
POSITION #l = ____
POSITION #2 = ____

# CHAPTER 3. Machine Components and Systems

## 3.1 SERIES I V2XT MACHINE

The V2XT is a vertical spindle, knee-type multi-function machine tool as shown in Figure 3-1. The equipment is built around a base assembly with a V-ram which carries the 2 hp milling head. The ram is mounted and secured to the column of the machine. The head is provided with limited adjustment.

Mounted to the machine column are the major accessories and control equipment shown in Figure 3-1:

- Operator Control Enclosure for the Operator's Control Station
- Auxiliaries Components for Lubrication and Pneumatics Systems

### 3.1.1 Base Assembly

The stability of the V2XT is a result of the single-piece cast iron column and base. This piece is internally ribbed and crossbraced for stiffness. Special dual knee locks (manually adjusted) clamp the knee to the column. The bearing area and single gib strip for adjustment in two places against the dovetail provides accuracy and rigidity with minimum vibration and wear. Ball leadscrews are placed centrally between symmetrical slideways; this provides balanced thrust at equal distances from the friction forces on two slideways. The machine ways are chrome-plated for long life and lubricated by an automatic one-shot system. The X-axis motor is mounted on the table and the Y-axis motor is mounted on the knee and rotates the Y-axis ballscrew.

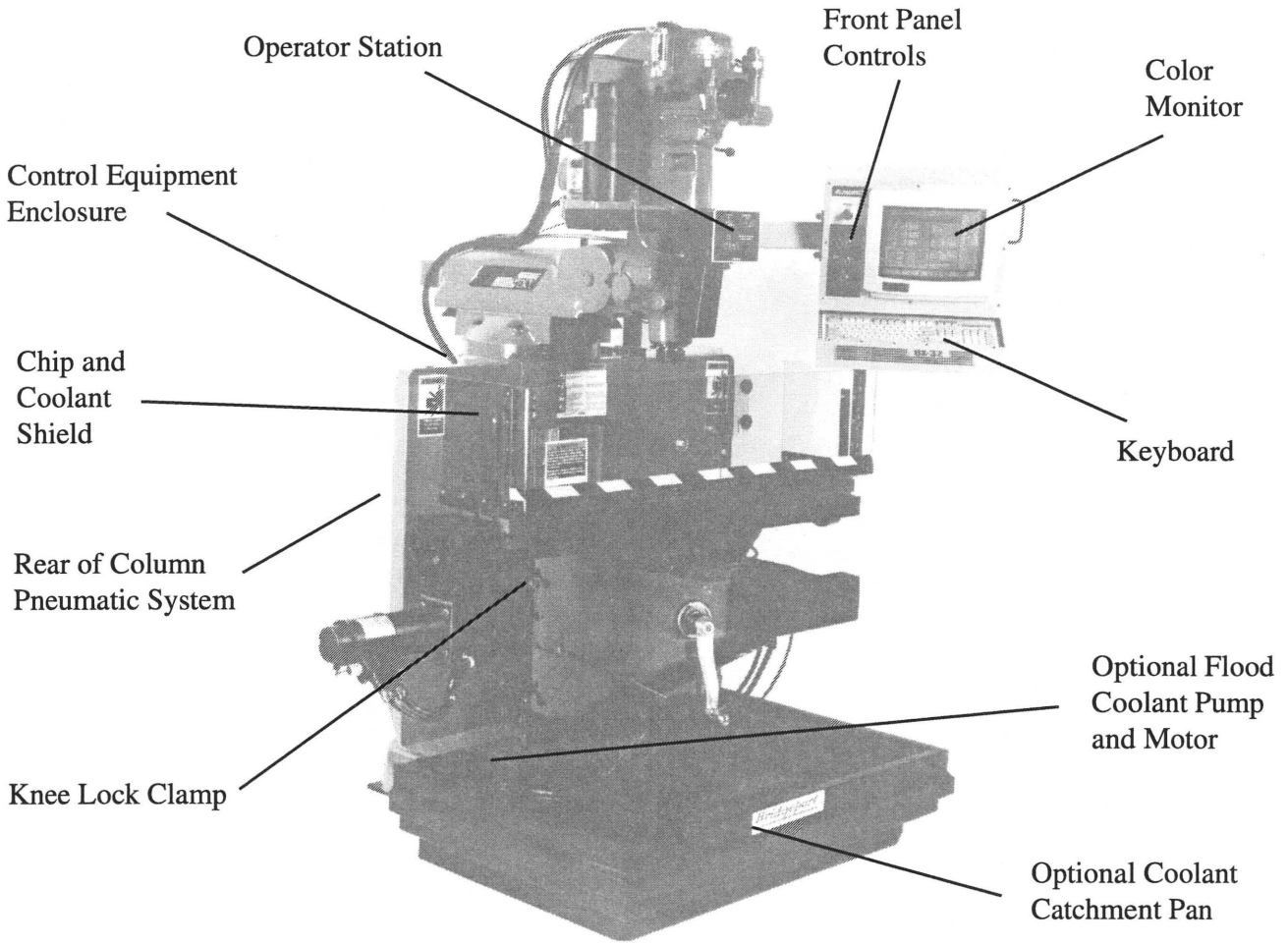



**Figure 3-1.** Series I V2XT

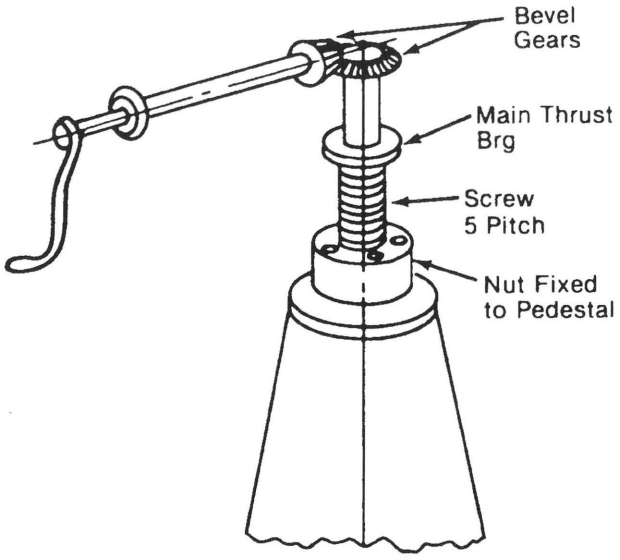



**Figure 3-2.** Knee Drive Transmission

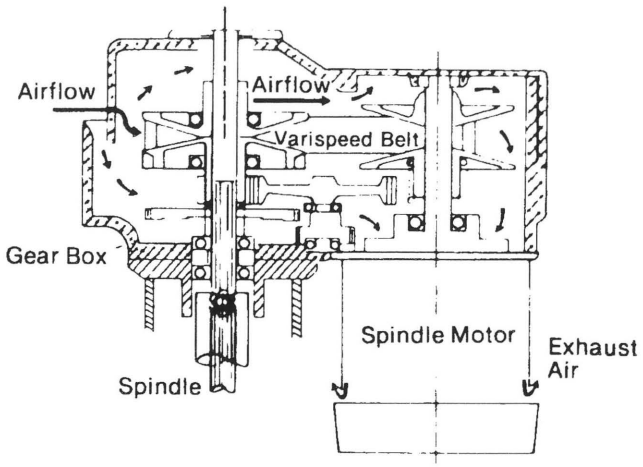



**Figure 3-3.** Spindle Drive Transmission

### 3.1.2 Knee Drive (Figure 3-2)

The knee is elevated by a 5-pitch Acme screw. A friction dial is provided, calibrated in increments of 0.001 inch (0.0254 mm).

To change the knee elevation, push the knee elevating crank in until the clutch meshes, then turn the crank clockwise to elevate the knee, or counterclockwise to lower it.

**NOTE**

Three knee lock handles (Figure 3-1) controlling the clamps on the knee-column ways must be released before the knee will raise or lower. The main knee lock is located on the left front of the knee. The other two knee locks are located on the left hand side of the knee.

To clamp the knee, firmly turn the knee lock wrench handles clockwise. To release, turn them counterclockwise. Keep the knee clamped while cutting. The knee is supported on an Acme screw, and the nut is mounted on the pedestal.

### 3.1.3 Gib Adjustment

The gibs are set properly at the factory before acceptance testing and alignment. Adjustment procedures apply only when misposition is evident or after about 6 months of use. We recommend that you do not try to reset the factory set gibs unless absolutely necessary. However, if gib adjustments are required, refer to Chapter 9 for the correct procedures.

### 3.1.4 The Milling, Drilling and Boring Head (Figure 3-4)

The spindle drive motor is a 3 phase, 2 hp (1 5W) ac induction motor. The following motors are available:

| | |
|---|---|
| 208/230/380/416/460V | 50/60 Hz |
| 575V | 60 Hz |

An internal cooling fan located within the motor casing draws ambient air into the front of the head, around the main drive belt and through the motor. See Figure 3-3.

Speed changing is affected by forcing the drive belt to ride at a large or small radius on the conically tapered varidisc sheaves. Each varidisc assembly is precision dynamically balanced to prevent vibration and promote long belt life.

When the high/low shifter is in high, the output of the varidiscs drives the spindle directly through the clutch. A shift into back gear (low) disengages the

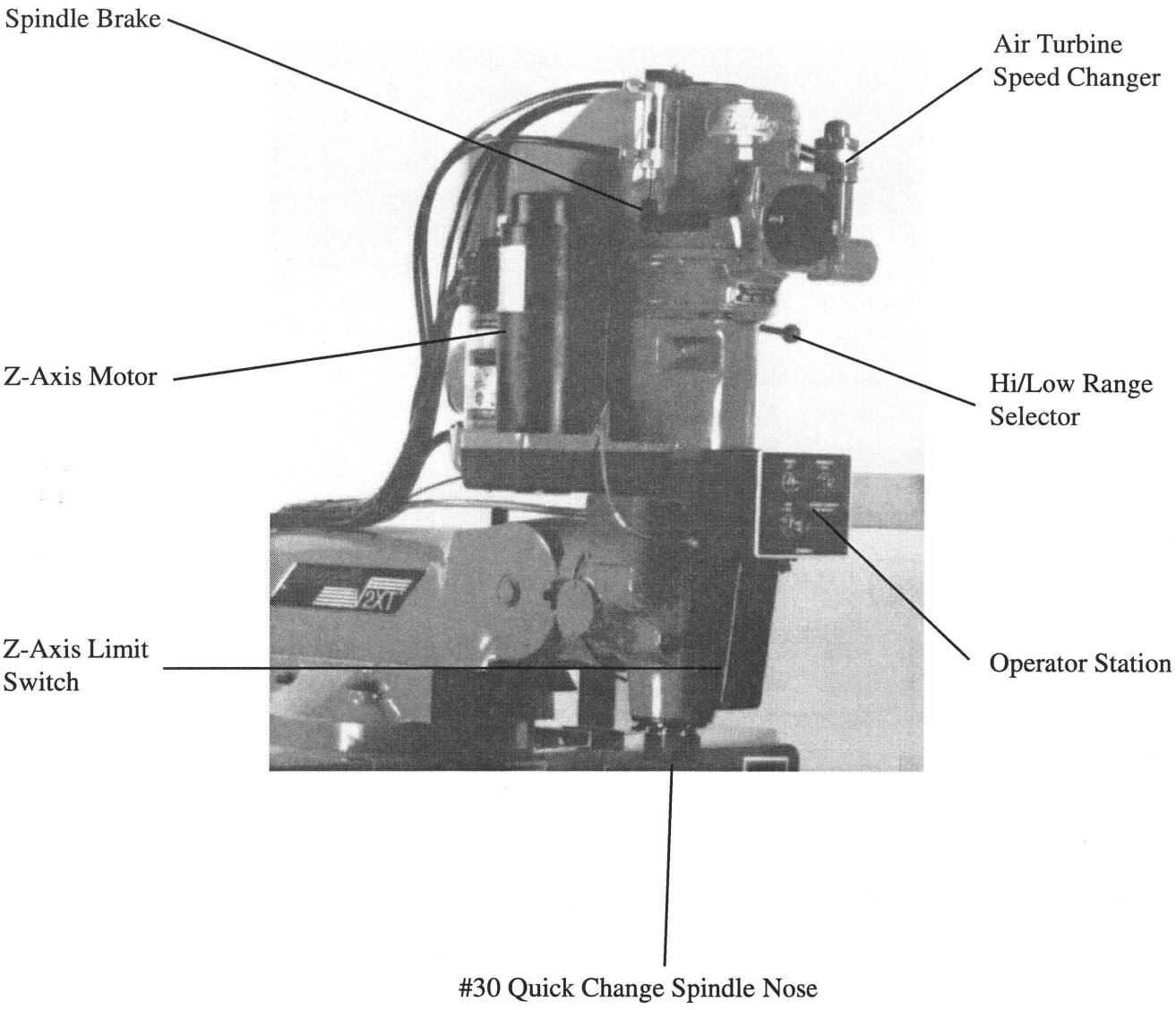



**Figure 3-4.** Milling, Drilling, and Boring Head

clutch and engages the bullgear. The power now travels through a toothed belt drive to a counter shaft and back to the spindle through the bullgear for an overall reduction of 8:92:1. A pneumatically operated spindle brake and speed changer are standard. See paragraph 3.6 for pneumatics.

### 3.1.5 Z-Axis Drive

The quill is driven by the same type of servo motor as the X and Y-axes. A timing belt connects the step motor and the ball quill extension. The ball quill has a 5-pitch thread carrying a recirculating ballnut with suitable internal preload. With proper adjustment of the timing belt, lost motion is virtually eliminated. The quill has a working travel of 5 inches. The drive ratio is 2:1 (0.2 lead).

### 3.1.6 The Quill and Spindle

The quill is a 3-3/8 inch diameter steel tube ground and chrome plated to a tolerance of 0.0002 inch. The quill secures the outer races of the angular contact, special precision, preloaded bearings mounted to the spindle. The spindle is alloy steel, hardened and ground with an involute spline at its upper end to slide internally in the power transmission train. At the lower end of the spindle a taper is ground for Erickson No. 30 quick change tool holders or similar units. A Universal 200 taper is also available.

## 3.2 THE CNC SYSTEM

The following sections provide a functional description of each subsystem in the V2XT system. Figure 3-5 is the BOSS DX-32 Functional Block Diagram of the system.

### 3.2.1 Operator Control Subsystem

The keyboard input is accomplished through this system. Machine status and all interactive menus

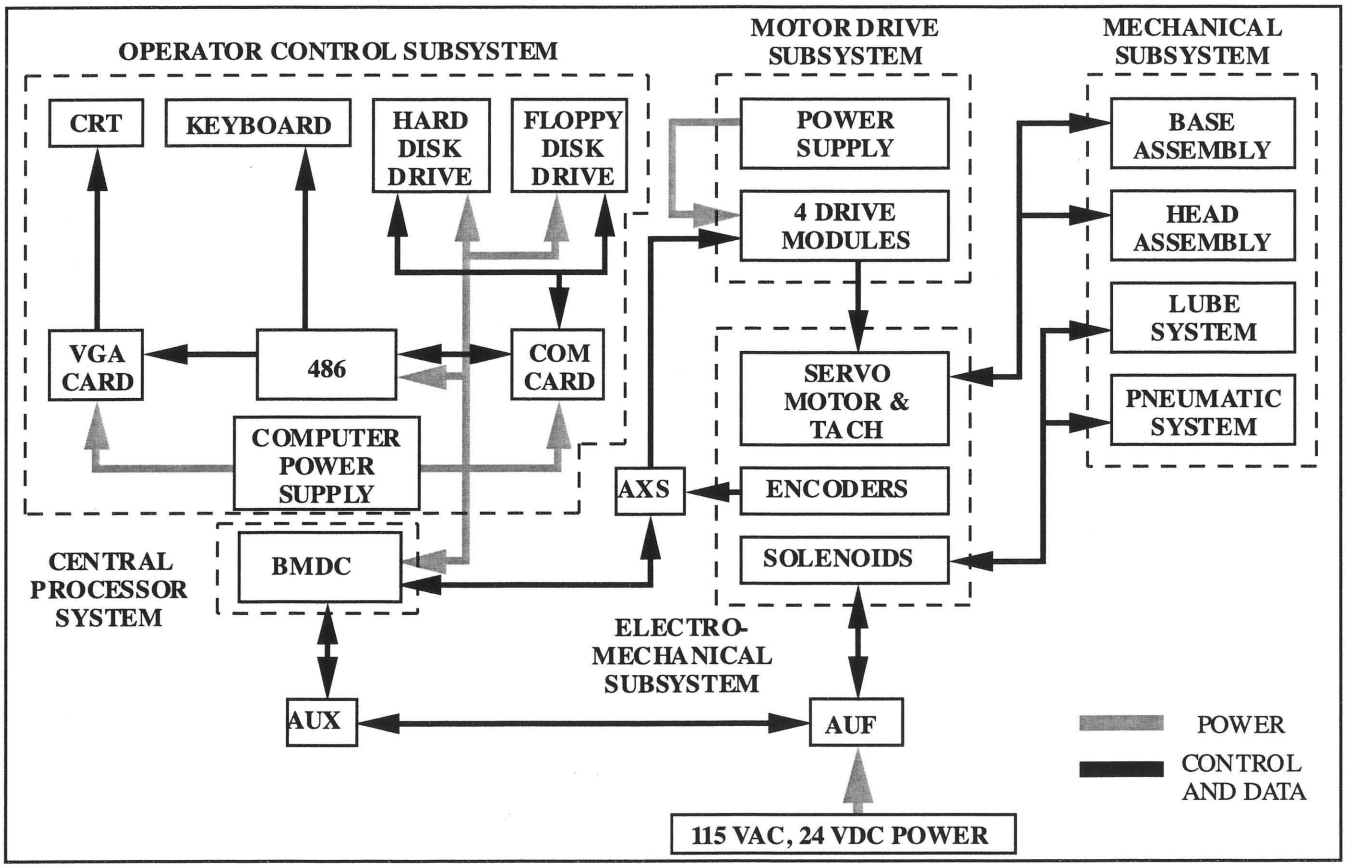



**Figure 3-5.** V2XT System - Functional Blocks

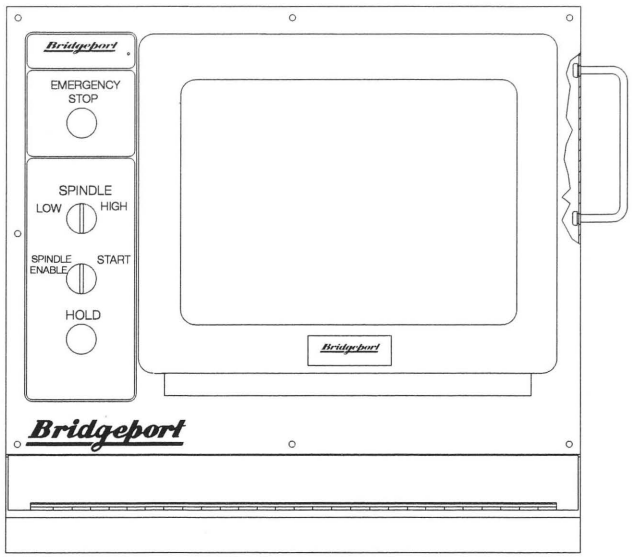



**Figure 3-6.** CRT and Front Panel Controls

are presented to CRT (cathode ray tube) through this system. All hard switches (Head control assembly and front panel switches) enter through the AUF board.

**486 Card -** This board is the controller of all programmed information. It controls the operation of theCRT, the keyboard, and the transfer of all information to an from the disk drive.

The disk drive stores all programs that are used by the machine including the operating system.

The Operator Control Subsystem is powered by its own power supply. It is a general purpose, 200W micro computer power supply.

### 3.2.2 Central Processing Subsystem

All operator and electronic output (EZ-LINK, paper tape, etc.) are analyzed by this subsystem. Appropriate commands and responses are sent to the Operator Control Subsystem, the Axis Drive Subsystem, or the Interface Subsystem. One board is in this subsystem:

**BMDC (Main Controller) Board -** The BMDC has control over all system operations and contains a 68030 microprocessor and memory allocations for both system firmware and part programs. It also processes encoder feedback and generates drive signals for the drive controllers. A complete description of the BMDC Board is presented in paragraph 5.5.

### 3.2.3 Power Subsystem

This subsystem contains two line voltage transformers and power supply which supply operating voltages to the entire V2XT system. Incoming power enters at the main disconnect and is conditioned and distributed by this subsystem. A complete description of the distribution of power through the V2XT system is presented in Chapter 4.

### 3.2.4 Interface Subsystem

Central Processing with control and status of the electromechanical components in the system provides an interface between the V2XT system and the outside world. This subsystem contains one board:

**AUF (Auxiliary Function) Board** - This board interfaces the Central Processing subsystem to the Electromechanical subsystem. It contains optocouplers and transistors used to control and monitor various electromechanical components such as limit switches, solenoids, relays, and panel switches. A complete description of the AUF board is presented in paragraph 5.8.

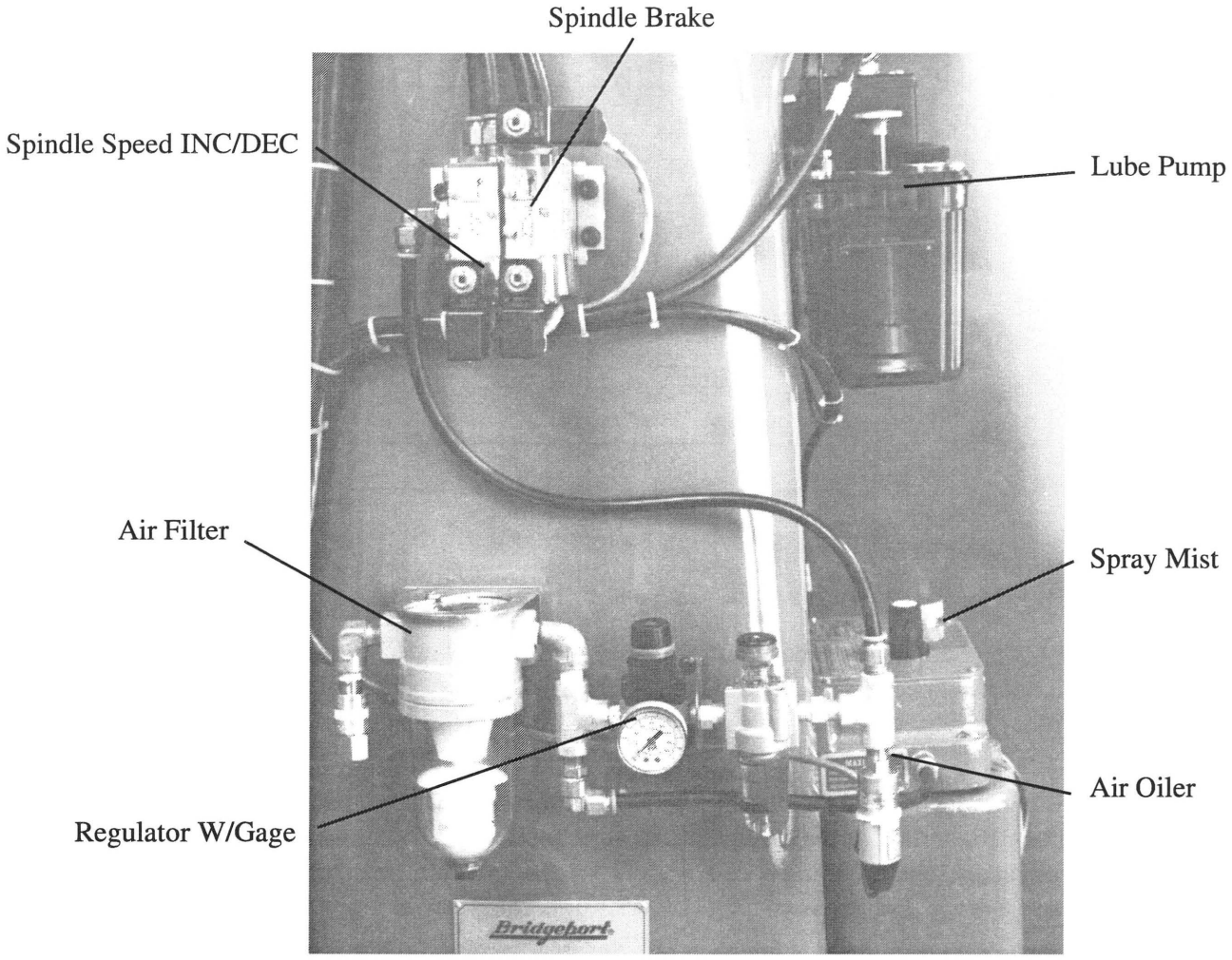



**Figure 3-7.** Auxiliaries Assembly

### 3.3 AXIS DRIVES

#### 3.3.1 Axis Drive Subsystem

This subsystem receives positioning signals from the BMDC board and translates these signals into command and direction signals for the dc servo motors.

This subsystem consists of an AXS board and three motor drive module assemblies.

The motor drive module assemblies send power and drive signals to the servo motors. The V2XT milling machine uses three motor drive module assemblies; one each for the X, Y, and Z-axes.

#### 3.3.2 Electro-Mechanical Subsystem

This subsystem receives commands and power from the servo drive subsystem, provides the axis motion of the milling machine, and receives position and velocity feedback signals from its respective axis. This provides the system with a positive closed loop servo for each axis. Each axis of the milling machine contains the following electromechanical assemblies:

1. Motor - The motor is a dc servo motor and receives current signals from the servo drive subsystem. The motor converts the signals into mechanical axis motion.

2. Encoder - The encoder converts the position of the axis into a two-phase pulse stream in addition to a home marker pulse, which is sent to the AXS board as an input.

3. Tachometer - The tachometer converts the velocity of the axis into an analog voltage signal which is sent to the axis drive subsystem as an input.

A complete description of the electromechanical subsystem is presented in Chapter 6.

### 3.4 MECHANICAL SUBSYSTEM

This subsystem contains two assemblies:

1. Head Assembly - This consists of all the mechanical components of the quill (Z-axis), the Z-axis drive motor and spindle motor.
2. Base Assembly - This contains the saddle (Y-axis), table (X-axis), knee, their support structures and the X and Y-axis drive motors.

### 3.5 LUBRICATION SYSTEM

#### 3.5.1 Overview

All bearings in the spindle, the spindle drive, transmission, and the ballscrew mountings have antifriction angular contact bearings greased for life. The automatic one-shot way lubricator system is shown installed in Figure 3-7.

#### 3.5.2 Way System Lubrication

All moving members are fed from a central lubricating tank, the TM-5 lubricator, which contains a filter and motorized timed plunger pump.

For more information on the lubrication system, refer to Chapter 11.

### 3.6 PNEUMATIC SYSTEM

#### 3.6.1 General Description

The entire pneumatic system is self-contained and requires no special start-up procedures other than the need for 80-125 psi service and adequately sized lines and plant equipment capacity.

The system consists of an air hose, a lubricator bowl, manual pressure relief valve, and a regulating valve set at 75 psi (482.5 kilo pascals). Average air consumption is 4 cfm. Instantaneous flow is 11 cfm, requiring lines and external equipment to be sized for 11 cfm.

Refer to Chapter 12 for more information on the Pneumatic System.

# CHAPTER 4. Power Distribution

## 4.1 INTRODUCTION

This chapter discusses the power distribution from its entry point at the Main Disconnect switch, through all of the transformers and power supplies to the various sub-systems. The System Wiring Diagram (1943101) is located at the end of this chapter.

## 4.2 SYSTEM OVERVIEW (Figure 4-1)

This is a 4 wire system (3 phases and a ground). After power enters the Power Equipment Enclosure, it passes through a disconnect switch, and fuses FU1, FU2 and FU3 before it is applied to the machine's power system for distribution. When received, the system will have been wired to conform to the customer's specifications, accepting one of the below listed line voltages:

208 vac 60 Hz
240 vac 60 Hz
480 vac 60 Hz

The incoming power is distributed into four branches as follows:

- Line voltage distribution - Line voltage is wired through a reversing/starting contactor for the spindle motor. When the contactor is activated, voltage is switched to the spindle motor.
- 120 vac single phase distribution - Incoming power is fed to transformer T1. T1 steps the line voltage down to 120 volts AC single phase. This voltage is used by part of the Drive Power Supply, and to power the operator sub system.
- 72 vac single phase - Line voltage is fed to transformer T2. T2 is a step down transformer. It steps the line voltage down to 72 vac single phase. This voltage is used by the Drive Power Supply which provides 105 vac to the motor drive module assemblies.
- 115 vac single phase distribution - This branch feeds transformer T2. T2 steps the line voltage down to 115 vac for use by the electromechanical devices in the system.

Two power supplies; Drive Power Supply and XT, deliver dc voltages to the following items:

The Drive Power Supply provides:

- + 24 vdc to the limit switches and pneumatics through the AUF board.
- + 24 vdc to the emergency stop and spindle for CW rotation switches on the front panel through the AUF.
- + 105 vdc to the motor drive module assemblies

The following sections describe the functional elements in the power system, see Figure 4-1.

## 4.3 SYSTEM PROTECTION

### 4.3.1 Signal Ground

Each module, separated device, or separate circuit, is referenced to the System Ground as close as practical to the System Ground Stud. Because these circuits branch out independently from the ground stud, they will not carry current from other modules. The Signal Ground (a zero-volt reference) is connected to the protective ground at only one point.

### 4.3.2 Shielding

Certain shielded cables for signal purposes are continuous shields grounded at one end only (the point closest to the System Ground Stud).

### 4.3.3 Noise Suppression

Suitable RC circuits are applied across ac relays and starters as well as at the main 3 phase ac induction motor for the spindle. DC relays are protected by diodes.

## 4.4 PROTECTIVE GROUND

Protective Ground (Chassis or Safety Ground) establishes a low impedance path from the equipment enclosure and other mechanical parts of the system to earth ground. Protective Ground assures that all conductive parts of the enclosure are safe. If any circuit inadvertently touches the chassis, the voltage will be reduced to zero and the enclosure will be safe to touch.

# 4. Power Distribution

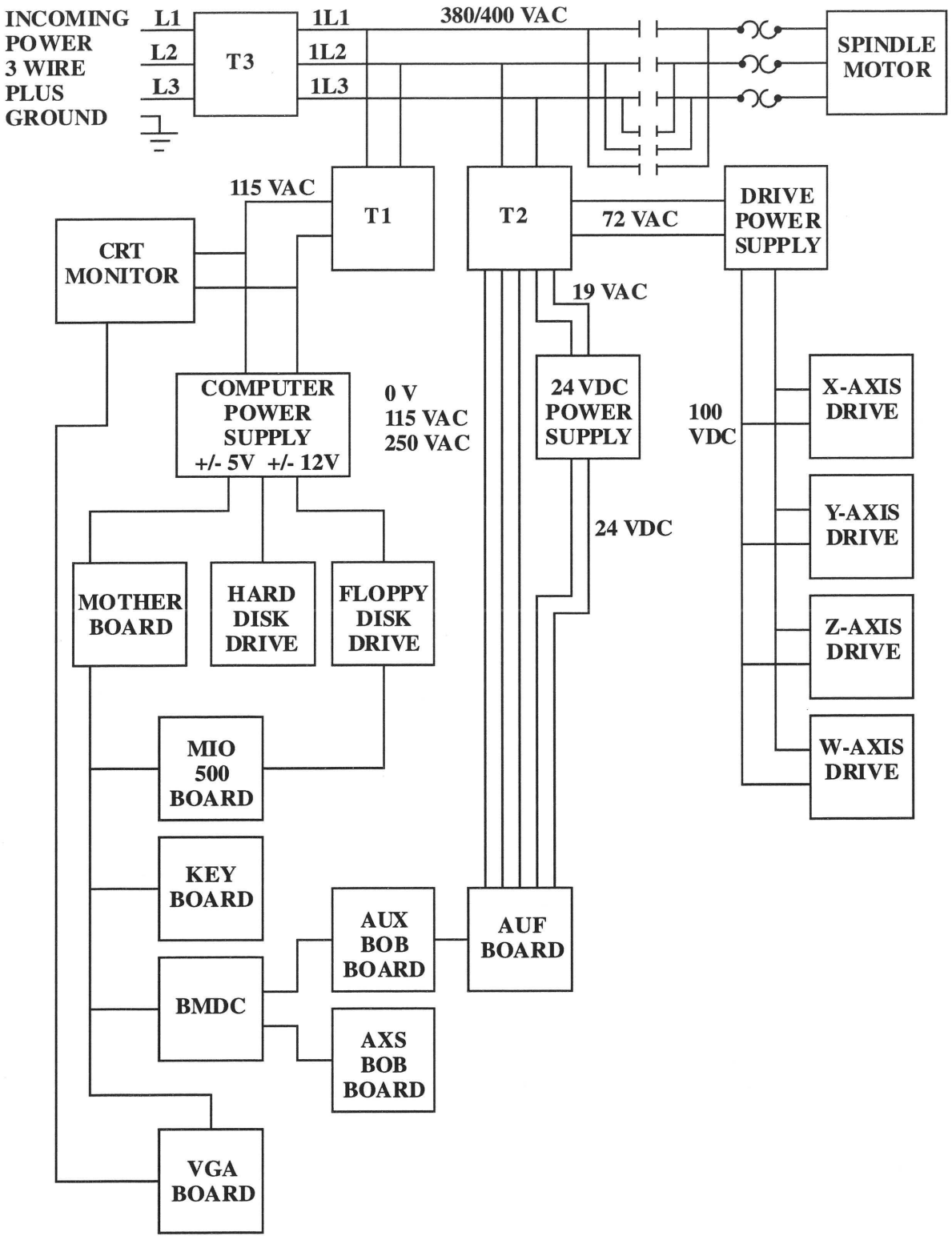



**Figure 4-1.** Power Distribution

# 4. Power Distribution

Protective ground is required. It minimizes the exposure to personal shocks in the event of circuit shorts or other malfunctions. Failure to ensure protective ground may create electrical shock hazard, causing serious personal injury or death.

Because safety requirements vary in different localities, be sure to consult local governing codes. These codes take precedence over the practical guidelines presented which are based upon:

- National Electrical Code;
- California "Electrical Safety Orders"; and
- Pennsylvania "Electrical Safety Regulations".

The three methods listed below are commonly used to establish earth ground:

**Continuous Metal Water Pipe** - When properly buried, length is installed below the permanent moisture level, impedance is typically 3 ohms.

**Copper Stake (3/4 in. dia.)** - When properly driven into the ground below permanent moisture level, the impedance of this type is typically below 5 ohms.

**Other Metal Electrodes (Well Castings or the Like)** - Must be well chosen since they generally exceed an impedance of 5 ohms but are well below 25 ohms.

The resistance of the earth ground connection is measured from the enclosure ground stud, through the ground wire, to the earth ground connection; then through the earth ground to another earth ground connection (at least 20 feet away), and through its associated wire to another ground stud. The resistance should not exceed 5 ohms. The wire used between the ground stud and the earth ground should be AWG10 or larger and should be braided cable to minimize resistance at high frequencies (cable resistance less than 0.075 ohm). The ground wire should be inspected for mechanical abuse periodically.

## 4.5 LINE VOLTAGE DISTRIBUTION BRANCH

This branch connects line voltage directly to the spindle motor. Contactors MF and MR switches incoming power from the line to the spindle motor.

### 4.5.1 Spindle Motor Protection

The spindle motor is a 3 phase 2 hp ac motor. Three heaters protect the spindle motors against excessive currents. If the current caused by the load is excessive, the overload heaters will stop current to the spindle motor by opening contact 1 MOL. After cooling, the heaters must be reset before the spindle motor can be restarted, see Table 4-1.

**Table 4-1.** Overload Heaters

| LINE VOLTAGE | PART NO. |
|---|---|
| 208/240 | 1542518 |
| 416/480 | 1542221 |

## 4.6 115 VAC DISTRIBUTION BRANCH

The 115 vac output from Tl feeds the XT Power Supply. The 115 vac distribution branch originates at transformer T2. T2 steps the line voltage down to 115 vac single phase. The following devices use 115 vac single phase.

- Lubrication motor
- System fans
- AUF board
- The Duplex receptacles

### 4.6.1 Lubrication Motor and System Fans

A motor located in the Auxiliaries Enclosure runs the pump that pressurizes the Waylube system. This motor turns on when either MF or MR is energized. Two fans cool the V2XT power and electronic systems. They receive their power directly from AUF Board. The two fans in the Control Equipment Enclosure are protected by 4 fuses on the AUF board.

### 4.6.2 AUF Board

The AUF Board uses 115 vac to power the following devices: mist coolant solenoid, flood coolant outlet, waylube pump motor, and the axis drive motor contactors. Power is supplied to each

of these devices in the following ways:

| Function | Out To Device |
|---|---|
| Mist Solenoid | JP20A - 1 & 3 |
| Flood Outlet | JP20B - 1 & 3 |
| Waylube Pump Motor | JP24B - 1 & 3 |
| Axis Drive Contactor | JP23A - 1 & 3 |

Signals from the BMDC board control the triacs located on the AUF board to allow activation of the ac devices. The flood and mist coolant signals are on only when the spindle is running.

### 4.6.3 The Duplex Receptacle

These are standard duplex outlets located on the right side facing the Power Equipment Enclosure. These are general purpose outlets capable of delivery 3A at 125V. These outlets are protected by fuses on the AUF Card.

## 4.7 24 VOLT POWER SUPPLY

The 24 volt power supply provides + 24 vdc power that is fed to the AUF board and is used by the following devices:

1. **Pneumatics** - A pneumatic cylinder clamps a mechanical brake against the spindle whenever the spindle is disabled for any reason. Power to the solenoids is provided when contactor MF or MR is closed, and one of the Spindle SPEED Control keys are pressed. Air passing through these solenoids rotates a pneumatic motor clockwise or counterclockwise. This motor moves levers in the head which expand or reduce effective diameters of the drive and spindle motor pulleys, changing the resultant spindle speed.
2. **Front Panel Switches** — The Front Panel switches provide communications between the machine and the operator. Power to the EMERGENCY STOP and the SPINDLE FOR C.W. ROTATION switches is from AUF board. The other switches are keyboard type; when pressed, they complete a path in the keyboard circuitry which causes the generation of a selected code element. The selected code element is transmitted to the machine controller (BMDC) board where the proper firmware is enabled to control the logic circuitry on the AUF board. This logic circuitry is used to control the electro-mechanical devices in the system.

**EMERGENCY STOP Switch** - When pressed, this switch will remove power from the spindle motor and contactor, causing the spindle to stop and remove power from CR1. CR4 is controlled by CR1. When pressed, the EMERGENCY STOP button will also remove power from the axis drive motors.

**SPINDLE FOR C.W. ROTATION** - This switch is used in conjunction with the SPINDLE ENABLE button. It determines whether contactor MF or MR operates. This switch is connected to the AUF board.

3. **LIMIT and HOME Switches**

**LIMIT Switches** - All axis limit switches are connected to the AUF board and operate on 24 vdc. The axis limit switches have the same effect on machine operations as the EMERGENCY STOP button. If any one of the limit switches open, 24 vdc is removed from the coils of the reversing contactor, turning the spindle motor off. The power is also removed from the axis drive.

**HOME Switch** - A switch is located on each axis. When a home switch is activated, a path is created to ground for the logic circuitry on the AUF board.

## 4.8 72 VAC DISTRIBUTION BRANCH

This distribution branch consists of a single phase step down transformer T2, and the Drive Power Supply. Transformer T2 can be wired to operate on either 208 vac, 240 vac or 480 vac line voltage. Line voltage is applied to the primary of T2. T2 steps the line voltage down to 72 vac. This 72 vac is applied to the Drive Power Supply: this changes the 72 vac to +105 vdc. This +105 vdc is used by the motor drive module assemblies to power the axis drive system.

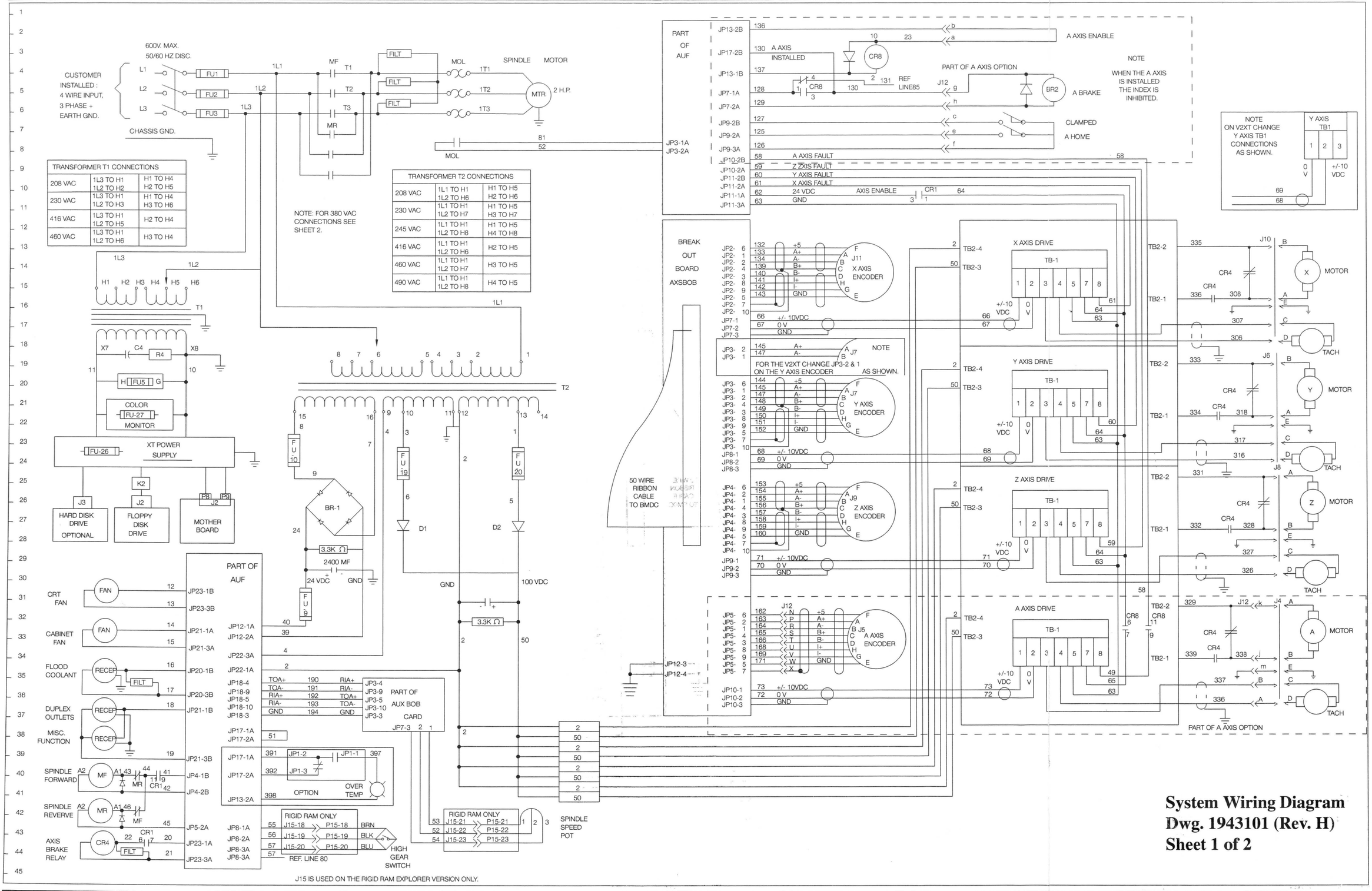
# 4. Power Distribution

**Table 4-2.** Fuse Chart

| FUSE CHART | | | | | |
|---|---|---|---|---|---|
| **FUSE #** | **VALUE** | **DESCRIPTION** | **PART #** | **LOCATION** | **REMARKS** |
| FU1,2,3 | 20 AMPS | FRS 600 VAC | 31508736 | DISC #1 | FOR 200/240 VAC |
| FU1,2,3 | 10 AMPS | FRS 600 VAC | 31508734 | DISC #1 | FOR 440 VAC |
| FU5 | .5 AMPS | MCR.5 600 VAC | 31542838 | TB-1 | |
| FU9,10 | 6 AMPS | MDA 250 VAC | 31508852 | TB-1 | |
| FU19,20 | 25 AMPS | FWN 250 VAC | 31541648 | TB-1 | |
| FU1A,2A,3A,4A,6A FU7A,8A,9A | 2.5 AMPS | 22902.5 250 VAC | 31542413 | AUF F1,2,3,4,6 AUF F7,8,9 | |
| FU5A | 10 AMPS | MDA 250 VAC | 31508852 | AUF F5 | |

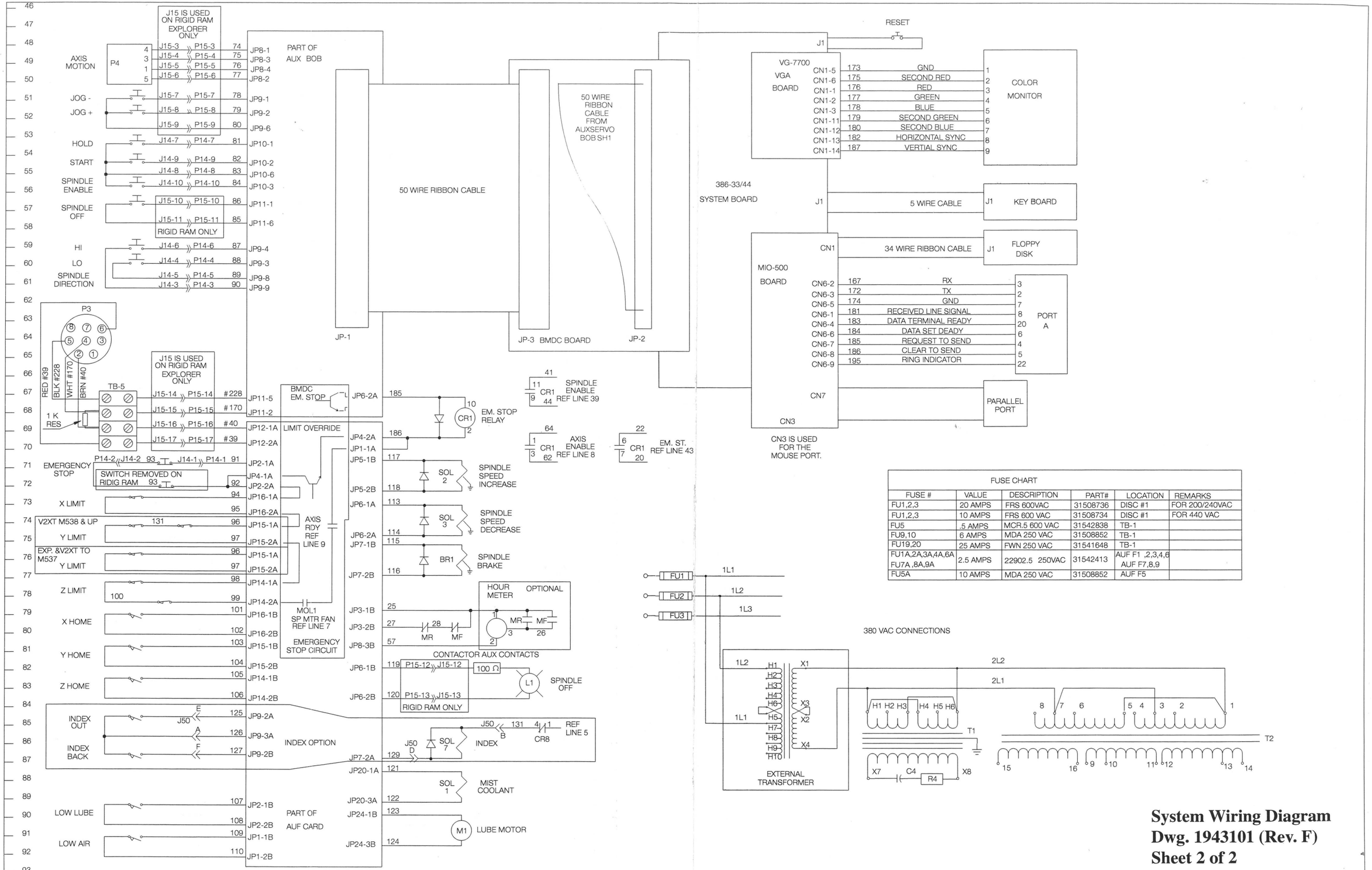
The + 105 vdc enters the controllers on terminal TB2-2, and ground is available to the controllers on terminal TB2-1.

# 4. Power Distribution




**System Wiring Diagram**
**Dwg. 1943101 (Rev. H)**
**Sheet 1 of 2**

# 4. Power Distribution




**System Wiring Diagram**
**Dwg. 1943101 (Rev. F)**
**Sheet 2 of 2**

# CHAPTER 5. Logic Boards

## 5.1 INTRODUCTION

This chapter deals with the logic boards in the V2XT DX32 system and describes what they do and how they interact with the whole system. Refer to the system block diagram, Figure 5-1 and Drawing 1943101 (Wiring Diagram).

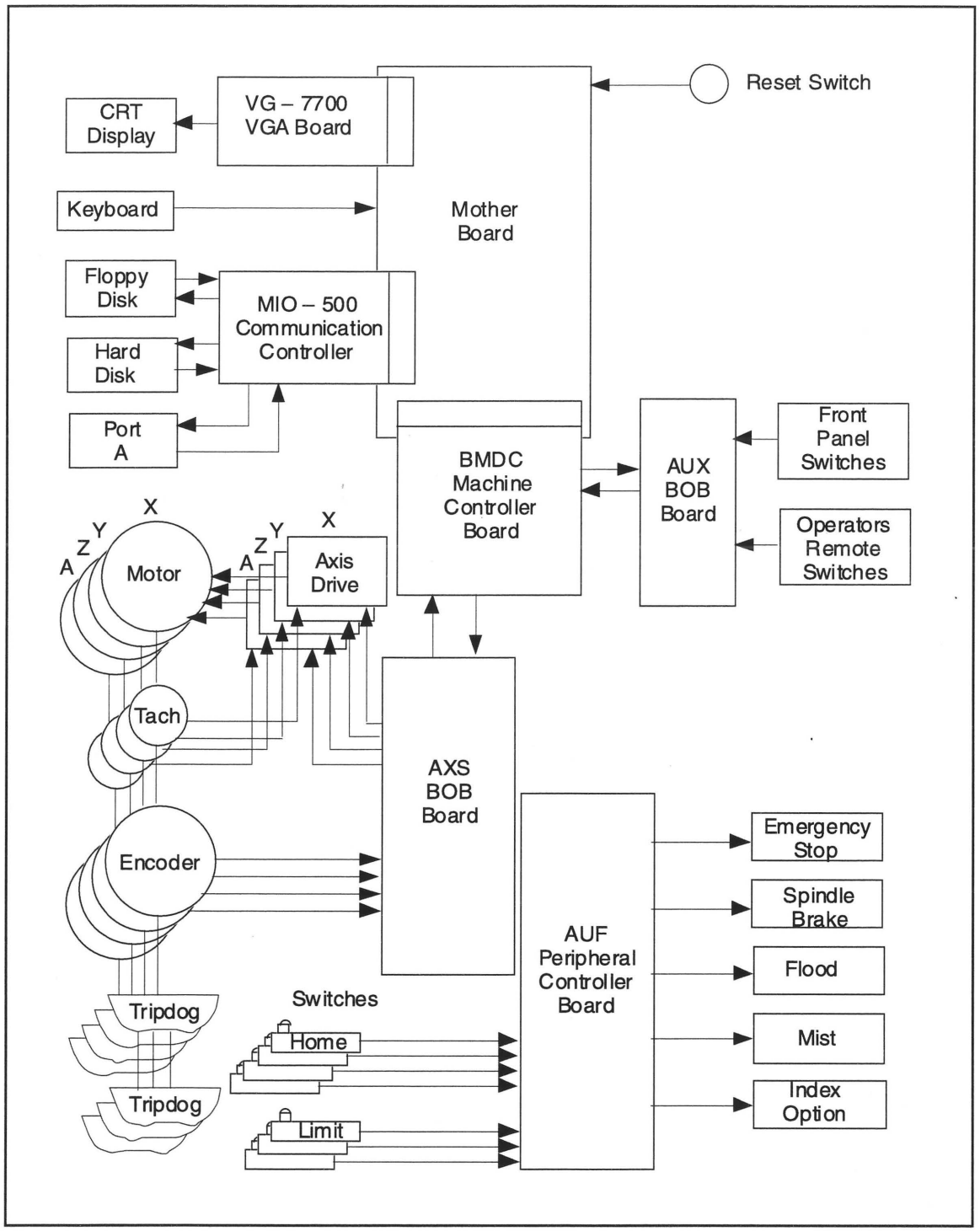



**Figure 5-1.** System Block Diagram

# 5. Logic Boards

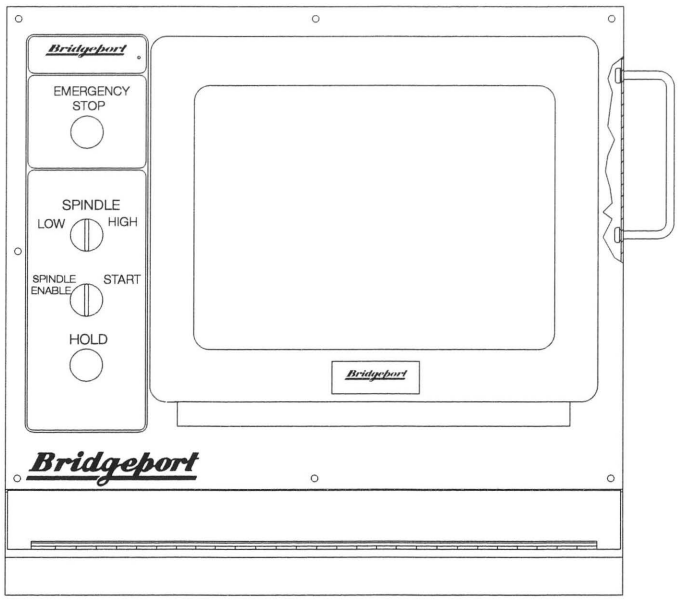



**Figure 5-2.** CRT and Front Panel Controls

CAUTION

**Static Sensitivity of the Boards**

All of the logic boards in the V2XT system contain static sensitive elements. Static electricity can be generated by walking across a floor. Unless grounding precautions are taken, touching a logic board will discharge electricity into the board; this will cause current to flow, possibly raising the temperature of internal junctions to their melting points. The damage can range from complete destruction of the board to hidden damage, resulting in limited life and premature field failure.

For instructions on handling static sensitive devices and grounding equipment, refer to Appendix A.

## 5.2 FRONT PANEL CONTROLS

There are four controls on the front panel that are not part of the keyboard. These switches are oil tight type operators that bypass the 486 processor and operate with the machine level logic. These controls are:

**Hold Switch** - This switch is a normally open momentary push button that causes the axis motion to come to a stop when it is depressed. This switch is connected to the AUXBOB board at JP10 pin 1 through wire 81 and pin 7 on connector J14. JP10-1 will go to +12 volts when this switch is activated.

CAUTION

The hold switch will not stop the spindle rotation or turn off the coolant.

**Start/Spindle Enable Switch** - This is a three position, spring return to center selector switch. When the Start position is selected, the control will start functioning in the automatic mode. The Start switch is connected to the AUXBOB board at connector JP10 pin 2 through wire 82 and pin 9 on connector J14. JP10-2 will go to +12 volts when this switch is activated.

When the Spindle Enable position is selected, the spindle will be enabled to start. This switch is connected to the AUX BOB board at JP10 pin 3 through wire 84 and pin 10 on connector J14.

JP10-3 will go to +12 volts when the switch is activated.

**NOTE**

The 12 volt source for the common to these three switches is through wire 83 and pin 9 on connector J14 to JP10 pin 6 on the AUXBOB board.

**Spindle High/Low Switch** - This is a three position spring return to center selector switch. This switch will cause either the Motor Forward contactor or the Motor Reverse contactor to be energized. It permits the selection of counterclockwise rotation of the spindle in either high or low gear.

The High position contact is connected to the AUXBOB board at JP 9 pin 3 through wire 88 and connector J14 pin 4 on one side and to JP9 pin 8 through wire 89 and connector J14 pin 5 on the other. The Low position contact is connected to the AUXBOB board at JP9 pin 4 through wire 87 and J14 pin 6 on one side and JP9 pin 9 through wire 90 and J14 pin 3 on the other.

Each of these signals will go to +12 volts when energized.

**NOTE**

The High/Low and the Spindle Enable switches must be energized at the same time to start the spindle.

**Emergency Stop** - This switch is a normally closed, push to open, pull to close, maintained contact switch. It causes all action to cease and removes power from everything except the control when depressed. The machine is equipped with two of these switches. One is on the front panel of the control and the other on the front on the spindle operators control station.
The Emergency Stop switch is connected to the AUF board at connector JP2 pin 1A through wire 91 and J14 pin 1 on one side and to the other Emergency Stop switch through wire 93 and connector J14 pin 2 on the other. The second side of the other Emergency Stop switch is connected to the AUF board at JP2 pin 2 through wire 92. +24 vdc is continuously flowing through these switches when they are closed.

### 5.3 AUXBOB CARD

**Description** - The prime purpose of this card is to break out the 50-wire cable which connects it to the BMDC board to separate connectors. This board has one 50-pin connector (JP1), two 10-pin connectors (JP2 and 3) that handle 4 wire communication to AUF expansion boards, one 10-pin connector (JP4) that handles optic isolated communication to a tool change expansion card, one 6 pin connector (JP6) that handles high current for switching relays, two 4 pin connectors (JP7 and 8) that handles the jog knob and feedrate override, and three 10-pin connectors (JP9,10, and 11) for handling general purpose low current inputs.

**Function** - This card delivers to the BMDC board the status of all the main interface switches. Over and above the front panel switches connected to it as described above, the following switches are also connected to it.

**Axis Motion Encoder** - This encoder is mounted out at the spindle in the operator's station. It will generate motion on the axis selected by the operator. The knob causes 0.1 inch of motion for each revolution when fast jog is selected and 0.01 inch of motion when slow knob is selected. The speed of the axis motion is controlled by the speed of rotation of the knob. 5 volts is supplied to the encoder at pin 4 through connector JP8 pin 1 on the AUX board and wire 74. 0 volts is supplied to the encoder at pin 1 through JP8 pin 4 on the AUX board and wire 77. The A channel signal is returned from the encoder at pin 3 to the AUX board through connector JP8 at pin 2 through wire 75. The channel B signal is returned from the encoder at pin 1 to the AUX board at connector JP8 pin 3 through wire 76. These signals are 0 to 5 volts and are in quadrature.

**Jog +/- Switch** - This switch is a two position, select and push switch. It causes the axis that is selected in the control to jog in the minus or plus direction for the period of time that the switch is

held closed. The speed of the jogged axis is either fast or slow and is preset in the software. When the minus direction is selected and the switch is pushed in, the signal at JP9 pin 1 on the AUX board through wire 78 goes to +12 volts. When the plus direction is selected and the switch is pushed in, the signal at JP9 pin 2 on the AUX board goes to +12 volts through wire 79. The common of these two switches is connected to JP9 pin 6 on the AUX board through wire 80 which is the source of +12 volts.

**Spindle Off Switch** - This switch is a lighted push button. If it is pushed while the spindle is running, the spindle motor shuts off, the spindle brake comes on, and the green light comes on to indicate that the spindle is safe. +12 volts is supplied to the switch from JP11 pin 6 on the AUX board through wire 85. The return signal is through wire 86 to connector JP11 pin 1 on the AUX board. The spindle off light and the spindle brake is connected to the AUF board and is discussed later.

**Probe Connector** - There is a separate connector supplied at the operator's station panel that is designed to supply voltage to and accept the signal from a probe attachment. +24 volts is supplied to the probe from JP12 pin 1A on the AUF board through wire 40 to pin 2 on connector P3. 0 volts (ground reference) is supplied from JP12 pin 2A on the AUF board through wire 39 to pin 6 on connector P3. The switch in the probe is supplied a signal 0 volts (5 volt ground reference) from JP11 pin 5 on the AUX board through wire 228 to pin 5 on connector P3. The return signal is brought to the AUX board at JP11 pin 2 from pin 4 on connector P3 through wire 170. The signal is pulled up to 24 volts by a resister on terminal block TB5 and it goes to 0 volts when the probe is displaced from neutral.

**Spindle Speed Pot** - This potentiometer is mounted on the front of the spindle assembly and returns a signal proportional to the speed of the spindle. This signal is used to set the spindle speed from the control. +12 volts is supplied to the potentiometer at pin 1 from the AUX board at JP7 pin 1 through wire 53. -12 vdc is supplied to the pot at pin 3 from the AUX board at JP7 pin 3 through wire 54. The signal is returned from the pot at pin 2 to the AUX board at JP7 pin 2 through wire 53. This signal varies from -12 vdc to +12 vdc.

### 5.4 MOTHER BOARD

**Description** - This board is a general purpose 486 digital processor operating at 33 megahertz with 4 megabytes of RAM. This board must be expanded to complete all computer functions necessary to meet the functional requirements of this control. Therefore, it has 8 expansion slots on it. These slots are populated with a VG-7700 VGA board, a MIO-500 communication board, and a BMDC machine controller board.

**NOTE**

The 4 MB of RAM memory reside on a small PC board that is plugged into the mother board and held into the socket by plastic tabs. These tabs can come loose, permitting a poor contact at the connector. When this condition exists, the processor will not boot-up correctly. To remedy, carefully remove the memory board and reseat the card in the socket. Ensure that the board is hooked under the small tabs.

**Function** - The motherboard handles all communications related to the part program. It receives information directly from the keyboard. All information received from or passed to the Floppy Disk, the Hard Disk, and the external Port A is through the MIO-500 communication controller. All information displayed on the CRT is ported through the VG-7700 VGA board.

### 5.5 BMDC CARD

**Description** - The Bridgeport Machines Drive Controller (BMDC) board is a low cost, high performance general purpose machine tool controller that is IBM AT bus compatible. The board and its companion software is designed to be

a general purpose, five axes control with the following features:

1. 25 Mhz 32 bit microprocessor (MC68EC030) provides a powerful platform with sufficient computational "horsepower" to allow additional features to be added.
2. 25 Mhz Floating Point Coprocessor (MC68882) provides fast and accurate (80 bit) arithmetic.
3. 512K bytes of High Speed Static memory for Control software and User data and/or programs.
4. 4096 bytes of Dual Port Memory to facilitate communication between the Host processor (286/386/486) and the 68EC030.
5. Five axis Position Encoder inputs. The encoder inputs may be either single ended TTL/HCMOS compatible, or RS-422 differential. Inputs for each channel include Phase A, Phase B, and Index.
6. One Quadrature encoder input for Operator Input such as a "Jog Knob". The Phase A, Phase B inputs must be single ended TTL/HCMOS compatible.
7. Four 12 bit DACs for outputing +/-10 volt commands to the four axes amplifiers.
8. One 16 bit DAC for outputing +/-10 volt commands to a fifth axis, typically a spindle.
9. Eight channel 8 bit Analog to Digital converter. Four channels are used to perform diagnostics, four channels are available for operator controls such as joy sticks or feedrate override pots.
10. Two Serial I/O communication Ports for auxiliary I/O through optional AUF and/or TLAUF boards, or to control "digital axis drive systems".
11. Eleven bits of general purpose input, typically used for operator switch inputs.
12. One Bit of input that can be used to " Take a snap shot" of the axes positions. This is often used for "Probing".
13. Two relay driver outputs rated for 60 vdc and 1 amp.

The BMDC board is plugged into a standard IBM AT compatible mother board. The Bridgeport Operating System Software (BOSS) is responsible for providing the interface to the machine operator (through the VGA screens and the keyboard), as well as networking capability with other computer based systems. The BOSS software for BMDC is also responsible for interpreting the user's part program, controlling the machine's axes servos, and other auxiliary functions such as coolant, lube, spindle, etc.

The BOSS software resides on a floppy or hard disk drive on the DOS machine. On power-up, the BOSS software on the DOS machine loads the main memory of the 68EC030 with BMDC BOSS software. The DOS BOSS software then enables the 68030 to run. The BMDC software then performs its power-up diagnostics and the begins its normal operation. Once the BMDC board is running, all communication between the DOS BOSS software and the BMDC BOSS software is performed through the dual port memory on the BMDC board.

The BMDC board is compatible with most IBM AT compatible systems. There are two requirements:

1. The I/O addresses 1A0 through 1B6 (hex) are reserved for use by the BMDC board
2. The Memory addresses D4000 through D4FFF (hex) are reserved for use by the BMDC board.

In some PC systems, these addresses may be in use for other boards and/or features. Often, conflicts may be fixed by changing addresses on the other boards and/or changing the system configuration information in the battery backed ram on the AT mother board.

The I/O for the BMDC board is through two 50 pin connectors (JP2, JP3). JP2 is for the analog commands to the axes drives and feedback from the axes encoders. JP3 is for the parallel and serial I/O.

For ease of system wiring, JP2 is ribbon cabled to the AXSBOB board and JP3 is ribbon cabled to the AUXBOB board.

The BOB (Break Out Boards) boards provide many small connectors for smaller cable harnesses, and some system specific circuitry such as termination registers and filtering circuitry.

### 5.5.1 BMDC Application Notes

The BMDC board requires +5 vdc at 3 amps. If the axes encoders are plugged to the BMDC board and obtain their power from the BMDC board, then the current requirement for +5 vdc will increase. Typically, four axes of encoders requires an additional 1.0 amp of current. The BMDC does not need any positive or negative 12 vdc from the AT bus connection, but if an external device such as a "Joy Stick" is connected, then sufficient +/-12 vdc current must be supplied.

If the axes encoder outputs are RS-422 differential, then termination resistors must be supplied. The AXSBOB board which is typically used with the BMDC board supplies the proper termination resisters. If the encoders provide only single ended outputs, then the termination resistors on the AXSBOB board must be removed. (RN1 for X-axis, RN2 for Y-axis, RN3 for Z-axis, RN4 for W-axis, and RN5 for S-axis).

If single ended encoder outputs are to be connected to the BMDC board and/or the AXSBOB board, then follow this guideline: If the encoder signals are TTL level (0.8 vdc to 2.4 vdc), then connect them to the plus inputs (+). If the signals are HCMOS level (0.5 vdc to 4.5 vdc), then connect them to the minus (-) inputs.

The axis encoder line rate (line count times the encoder rotational speed) is limited to a rate of 127,000 lines per second. This limits the axis position counters to 508,000 counts per second.

An example:

A 1,000 line encoder at 3,000 RPM (50 revs/sec.) will generate a line rate of 50,000 lines per second or 200,000 counts per second.

### 5.5.2 Diagnostic Software Features

There are four types of diagnostics that are available for the BMDC board:

1. There are software routines that run on the DOS machine that can check the basic functionality of the BMDC by directly accessing the 68030's bus and its devices.
2. The 68030 has its own software routines within BMDC BOSS that also check the BMDC board. The 68030's routines run faster and are more extensive then the DOS based diagnostics.
3. There are checks performed by the BMDC software during normal operation that monitor the behavior of the system. If a run time check detects a problem, a note of the problem and the time and date is placed into the Event Queue. The Event Queue may be read with a program running on the DOS machine. The event queue is *VOLATILE.* If the system is powered down, the information in the queue is *LOST.*
4. The fourth type of diagnostic software is called the Window Monitor. The window monitor allows a technician to read and write memory and I/O on the BMDC while normal system operation continues. The Window Monitor consists of software that runs on the DOS machine and software that runs on the 68030. The two parts of the window monitor software communicate with each other through the dual port memory.

### 5.5.3 Quick Check for Proper BMDC Operation

At Power-Up, the LED D1 should be ON and LED D10 should be OFF. When the BMDC is loaded with BOSS software and started, the LED D1 will turn off and D10 will Blink on and off. At the successful completion of the power up tests, LED D10 will begin to blink !! LED D11 (if installed) will glow dimly during normal operation. If D11 is glowing brightly, then the 68EC030 has suffered a DOUBLE BUSS FAULT or the board was reset.

### 5.5.4 Status LEDs

The BMDC boards have three status LEDs, a "RESET" LED, a "HALT" LED, and a "STATUS" LED. The Reset LED is on when the BMDC board is powered up or when the Host computer issues "RESET" command. The HALT LED is on if the BMDC is in a reset state or if the 68030 has detected a severe fault. Under normal conditions, the HALT LED will glow dimly. The STATUS LED is off at power up or after a RESET command. The 68030 power test software will blink this LED as it begins its BMDC tests. If the tests are successful, the status LED will blink on and off as the 68030 runs its normal system software.

**BMDC1, BMDC2**

Reset Led = D1 (next to U1, MC68882)
Halt Led = D11 (next to U3, MC68EC030)
Status Led = D10 (next to U34, NUATDEC)

**BMDC3**

Reset Led = D1 (next to U2, MC68882)
Halt Led = D2 (next to U2, MC68882)
Status Led = D3 (next to U21, 2681)

### 5.5.5 Function in System

The BMDC has the basic function of controlling the position of the motors at all times. It does this by commanding the velocity of the axis motors through the AXSBOB card and receiving the output of the motor encoders and the spindle encoder through the AXSBOB card. This board computes the new commanded position each 500 micro seconds and corrects the velocity of the motors to get there. This board also monitors all switches and issues commands to other control functions through the AUXBOB card to the AUF board.

## 5.6 AXSBOB CARD

**Description** - The prime purpose of this board is to break out signals from the BMDC board to separate connectors. The AXSBOB (break out board) has one 50 pin connector (JP1) that is used to connect this card to the BMDC board through a 50 wire ribbon cable. It also has 6 four pin connectors (JP 7 through JP12) and 7 ten pin connectors (JP 2 through JP 6, and JP13 and 14). The assigned use of these connectors are as follows:

JP2 returns the encoder signals from the X-axis.
JP3 returns the encoder signals from the Y-axis.
JP4 returns the encoder signals from the Z-axis.
JP5 returns the encoder signals from the A-axis.
JP6 returns the encoder signals from the spindle axis.
JP13, and 14 are spare input connectors.
JP7 outputs the velocity command to the X-axis.
JP8 outputs the velocity command to the Y-axis.
JP9 outputs the velocity command to the Z-axis.
JP10 outputs the velocity command to the A-axis.
JP11 outputs the velocity command to the spindle axis.
JP12 is a spare ground connector.

**Command Outputs** - Pin 1 on the above connecters is the +/- 10 volt analog signal to drive the axis. Pin 2 is signal ground. Pin 3 is shield ground. For X-axis JP7 pin 1 is connected to the amplifier at pin 1 through wire 66. JP7 pin 2 is connected to the amplifier at pin 2 through wire 67. For the Y-axis, JP8 pin 1 is connected the amplifier at pin 2 through wire 68 and JP8 pin 2 is connected to the amplifier at pin 1 through wire 69. For the Z-axis, JP9 pin 1 is connected to the amplifier at pin 1 through wire 71 and JP9 pin 2 is connected to the amplifier at pin 2 through wire 70.

**Encoder Inputs** - In the chart below, the column of numbers on the left is the pin numbers on the connector JP2 through JP6 as listed above. The column of letters A through G are the pins in the connector at the encoder.

| AUF Connector | Encoder Connector | | |
|---|---|---|---|
| | X | Y | Z |
| 1 | A | B | B |
| 2 | B | A | A |
| 3 | D | D | D |
| 4 | C | C | C |
| 5 | E | E | E |
| 6 | F | F | F |
| 8 | H | H | H |
| 9 | G | G | G |

Pin 1 is the channel A+ input. Pin 2 is the channel A- input. Pin 3 is the channel B- input. Pin 4 is the channel B+ input. Pin 5 is the system ground output. Pin 6 is the +5 vdc output. Pin 7 is the cable shield ground. Pin 8 is the channel index plus input. Pin 9 is the channel index minus input.

### 5.7 AUF BOARD

**Description** - The AUF board is a small programmed controller. It has a small quantity of local software that works in conjunction with the BMDC software to control several machine functions. Around the edge of this card is thirteen double stacked two pin connectors (JP1 through JP7 and JP12 through JP17) and nine double stack three pin connectors (JP8 through JP11 and JP20 through JP24). When these connectors are called out on the schematic,they are referred to as A or B level. A level will always be the top connector and the B level will be the connector closest to the PC card. There is two communication connectors having ten pins each, JP18 and JP19.

Connectors JP1, JP2, JP3, JP14, JP15, JP16, and JP17 have three pin program pins on headers. They are labeled H1 through H7. H1 through H6 is used to describe the length of the limit switch string and H7 changes the gender of the signals on input I1 through I7. On this card H2, H3, H4, H5, H6, and H7 are jumpered between 2 and 3 while H1 is jumpered between 1 and 2.

This card contains nine fuses. They are used to fuse the incoming ac to the board and fuse the ac outputs. Refer to the second page of the schematic in this manual for there value and size. This card has four 120 ac @ 4 amps switched outputs and seven 24 vdc @ 2 amps switched outputs.

Switch S1 is a set on four switches that define the baud rate and card address for purposes of expansion. In a single AUF card system these switches are all set to off. Any other switch combination can negate the communication to this card.

**Function** - The function of this card to command external functions to begin through its switched outputs and observe the progress of the function through input switches. As the changed states occur, the AUF reports the function progress to the BMDC card through the four wire communication system at connector JP18.

#### 5.7.1 AUF Input Functions

**Supply Voltages** - The supply voltages used on the AUF board is 24 vdc and 115 vac. The 24 vdc is supplied to the board at JP12 pin 1A through wire 40 from fuse 9 on the output of the 24 vdc power supply. 0 vdc is supplied to the board at JP12 pin 2A through wire 39 from the 24 vdc power supply. 115 vac is supplied to the board at JP22 pin 3A through wire 4 from the output of T2 at terminal 9. 0 vac is supplied to the board at JP22 pin 1A through wire 2 from T2 terminal 11, 12 and chassis ground. The 115 vac input is fused on the board by fuse 5A.

**Low Voltage Power Supply** - The 24 vdc is used as the source for a +5 vdc power supply which is used to power the microprocessor on this board. The 24 vdc is filtered by a 220 MF capacitor as it enters the board. It then is feed through a diode to a second 220 MF capacitor filter and a 27 ohm resister. The output of the resister is inputted to a three terminal 5 vdc regulator. The output is again filtered.The maximum current capability of this supply is 1 amp.

**AUX to AUF Communications** - The communication format is RS-485 at 9600 baud rate. As many as 4 AUF boards can be connected to this

port in party line configuration. Each board has an address that is configured by a dip switch on the board. The AUF is address driven. It will not reply to the host until it has been addressed. If it is not addressed within one second, all outputs are reset. Information from the AUX to the AUF is from JP 3 pins 5 and 10 on the AUX through wires 192 and 193 to the AUF at JP18 pins 5 and 10. Information from the AUF to the AUX is from JP18 pins 4 and 9 on the AUF through wires 190 and 191 to JP3 pins 4 and 9 on the AUX. Ground for this port is supplied from JP3 pin 3 on the AUX through wire 194 to JP18 pin 3 on the AUF.

**Emergency Stop Circuit** - The emergency circuit (Figure 5-2) in this machine consists of two emergency stop switches (one on the Rigid Ram), the spindle motor overload, over temp switch (if it is installed), and the X, Y, and Z limit switches. The circuit starts at JP2 pin 1A where +24 vdc is supplied to one side of the Emergency Stop switch through wire 91 and J14 pin 1. The other side of the switch is connected to the second Emergency Stop switch through wire 93 and J14 pin 2. The 24 volts is returned from this switch to JP2 pin 2A through wire 92. JP2 pin 2A is connected to JP4 pin 1A. On the AUF board, the 24 volts at JP4 pin 1A is connected to the collector of a power transistor. The output of the transistor is connected to JP4 pin 2A and jumpered to JP1 pin 1A. The output on wire 186 is connected to pin 2 of CR1, the emergency stop relay. The other side of CR1 at pin 10 is connected to pin 2A on JP6 on the AUX board. This transistor circuit gives the control its limit over ride capability when the axis drive enable is energized from the control key board. If any of the axis is in it's limit, the transistor turns on while the control checks for an open limit switch and then enables the operator to jog of limit. If the control is not in a limit but something else in the string is out of order, the control will shut down after about 30 seconds and post an operator message describing the problem. If every thing is normal, the transistor is shut off after 30 seconds and CR1 is held energized through the limit string. The input to the AUX board at JP6 pin 2A, which supplies the ground path for the current through CR1, is controlled by the BMDC board and is used to put the control in to Emergency Stop if any of the axis motion is out of order.

The limit string is an extension of the signal from the two Emergency Stop switches which exits the AUF board at JP3 pin 1A on wire 81 to the spindle motor overload. On the other side of the overload, wire 52 returns the 24 vdc back to the AUF at JP3 pin 2A through wire 52. The 24 vdc is then connected to JP17 pin 1A were it is jumpered to JP17 pin 2A. (If an over temp switch is used, the jumper is removed and a normally closed contact takes it's place.) This signal is connected to JP16 pin 1A were it is taken to the X-axis limit switch through wire 94. The signal is returned from the switch through wire 95 to JP16 pin 2A. The 24 volts signal is wired to JP15 pin 1A on the AUF board were it is connected to the Y-axis limit switch through wire 96. The other side of the Y limit switch is connected to a second Y limit switch through wire 131. The output of the second switch is connected to the AUF at JP15 pin 2A. **NOTE:** On early models of V2XTs, only one Y limit switch was used and wire 131 was eliminated. The 24 vdc signal is jumpered to JP14 pin 1A were it is connected to the first Z limit switch through wire 98. Wire 100 connects the two limit switches. The other side of the second switch is connected JP14 pin 2A. This signal is hard wired on the AUF board to JP1 pin 1A. This series string of switches forms the holding circuit for CR1, the Emergency Stop relay, and anyone of them that is opened will force an Emergency. The Emergency Stop relay, when de-energized, removes power from the spindle motor and all axis motors. All of these switches are wired normally closed and activated open. All inputs in the emergency stop string is sampled by the BMDC and displayed in the operator's message area when they are activated.

**Home Switches** - This group of three switches are used by the control to arrive at reference (machine 0,0,0) each time the machine is homed. All

switches are wired normally open and activated closed. 24 vdc is supplied to the X home switch from JP16 pin 1B through wire 101. The signal is returned to JP16 pin 2B through wire 102. 24 vdc is supplied to the Y-axis switch from JP15 pin 1B through wire 103. The signal is returned to JP16 pin 2B through wire 104. 24 vdc is supplies to the Z-axis home switch from JP14 pin 1B through wire 105. The signal is returned to JP14 pin 2B through wire 106. All of these signals go to 24 vdc when the switch is closed.

**Low Lube Switch** - This switch is used to sample the level of oil in the way lube reservoir. If the automatic pump oil level is low, the operator is inhibited from starting the spindle. If the spindle is on when this signal goes false, the spindle will continue to run until the next MO5 or MO6. 24 vdc from JP2 pin 1B is connected to the switch through wire 107. The signal is returned to JP2 pin 2B through wire 108. This switch is wired normally open and activated closed by the oil level.

**Low Air Switch** - This switch is used to sample the air pressure that is supplied to the machine. This switch is wired normally open and activated closed by the air pressure. This switch is set to trip closed at 50 psi. When the pressure falls below 50 psi, the control will display an alarm and a message to the operator "low air can't set spindle speed" when a spindle speed is requested. 24 volts is supplied to the switch from JP1 pin 1B through wire 109. The signal is returned to JP1 pin 2B through wire 110.

**High Gear Switch** - To make the spindle speed control effective, the BMDC board must know which gear has been selected on the head. The shifting mechanism is equipped with a proximity switch that is activated in the high gear position. This switch must be adjusted to 0.04 inch or less between the position lock on the gear shift handle and the end of the switch. 24 vdc is supplied to the switch from JP8 pin 1A through wire 55 to the brown wire on the switch. 0 vdc is supplied to the switch from JP8 pin 3A through wire to the blue wire on the switch. The signal from the switch is connected to JP8 pin 2A through wire 56 and the black wire on the switch.

**Spindle On Detector** - This circuit is designed to ensure that the spindle motor forward or reverse contactor had energized when it is requested. One normally closed auxiliary contact from each contactor is wired in series and connected to an input on the AUF. 24 vdc is supplied from JP3 pin 1B to a contact on MF contactor through wire 25. The output of the MF contact is connected to the input on a MR contact through wire 28. The other side of the MR contact is returned to JP3 pin 2B through wire 27. If the motor is off, JP3 pin 2B is at 24 vdc.

### 5.7.2 AUF Output Functions

**Fan and Receptacle** - These three output functions are not switched. The are connected to 115 vac through fuses on the board and are active at all times that the power is applied to the control. The fan to the CRT enclosure is supplied power from JP23 pins 1B and 3B through wires 12 and 13. This circuit is protected by fuse 6A. The control enclosure fans are supplied power from JP21 pins 1A and 3A through wires 14 and 15. This circuit is protected by fuse 4A. The duplex receptacle on the side of the cabinet is supplied power from JP21 pins 1B and 3B through wire 18 and 19. This circuit is protected by fuse 3A.

**Flood Coolant** - This output is 115 vac and is switched on when flood coolant requested by the control. The output at JP20 pin 1B is 0 vac and connected to the coolant through wire 16. The output at JP20 pin 3B is switched to 115 vac and connected to the coolant through wire 17. This circuit is protected by fuse 2A.

**Axis Brake Relay** - This relay is a is capable of switching 200 vdc at 50 amps and has 3 poles that are double throw. One normally open contact of each pole is in series with the dc motor armature and the output of the axis drive card. The other normally closed contact is shorted around the armature of the motor. When this relay is

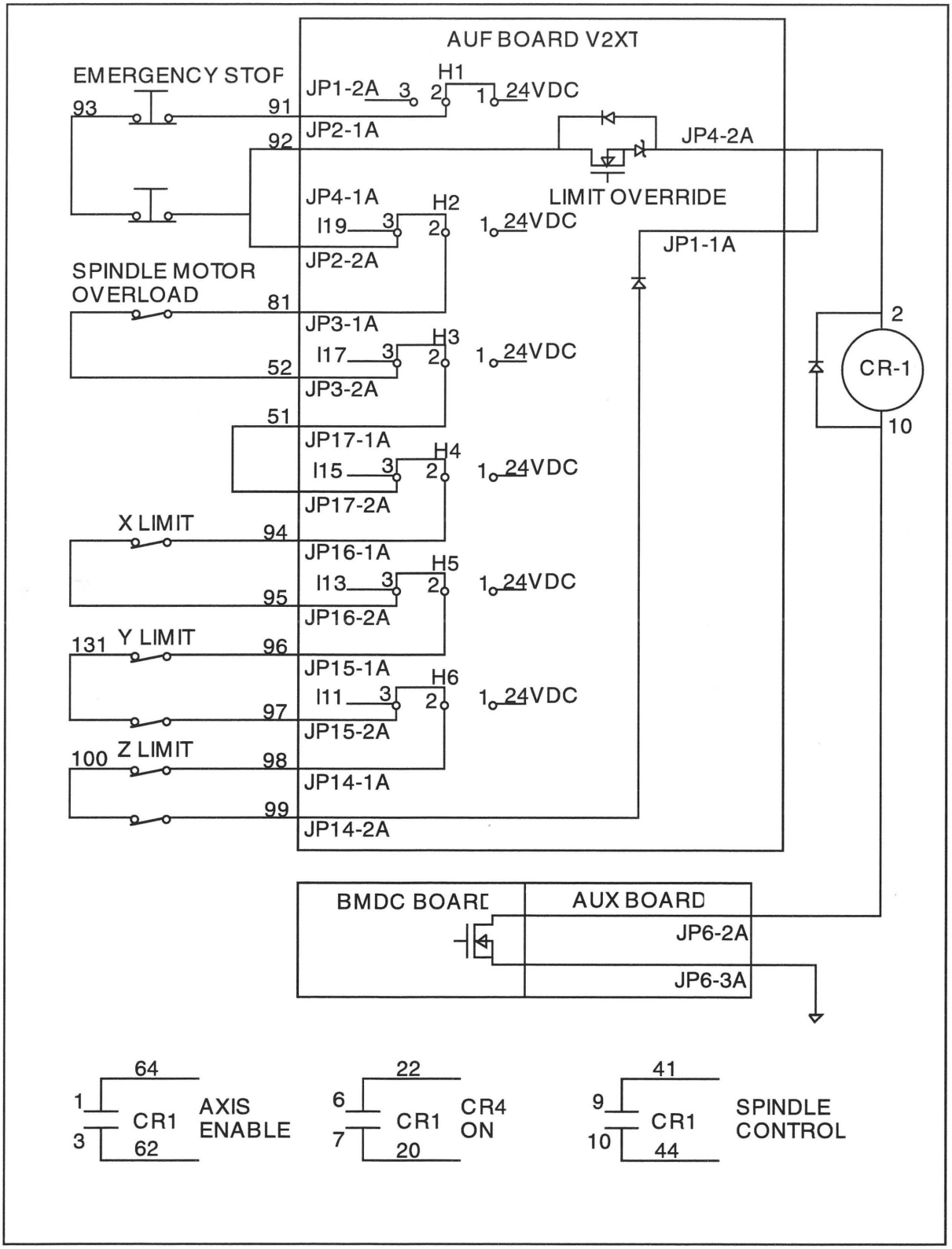



**Figure 5-3.** Emergency Stop Circuit

energized, the motor is connected to the amplifier. If emergency stop is requested, the motor is disconnected from the amplifier and the armature is shorted to force dynamic braking to stop the motor. This relay is energized when the Axis Enable is selected by the control operator and is de-energized by the emergency stop circuit. 0 vac is supplied to this circuit from JP23 pin 1A to CR1 pin 7 through wire 20. Pin 6 on CR1 is connected to the relay through wire 22. CR1 is the Emergency Stop relay. 115 vac from JP23 pin 3A is supplied to the relay through wire 21. This circuit is protected by fuse 7A.

**Mist Coolant** - This output turns on the mist coolant solenoid when requested by the control. 0 vac is supplied to the coil from JP20 pin 1A through wire 121. The 115 vac is supplied from the switched output JP 20 pin 3A to the other side of the coil through wire 122. This circuit is protected by fuse 1A.

**Lube Pump Motor** - The lubrication pump is switched on when the spindle is turned on and switched off when the motor is turned off. 0 vac is supplied to the pump coil from JP24 pin 1B through wire 123. 115 vac switched is supplied to the coil from JP24 pin 3B through wire 124. This circuit is protected by fuse 8A.

**Spindle Motor Forward/Reverse** - This reversing contactor consists of two motor contactors that are mechanical interlocked and by wiring, electrical interlocked to prevent the possible of both of them being energized at the same time. They are forced to de-energize by a contact of CR1 when Emergency Stop is requested. 24 vdc is supplied from JP4 pin 1B to a normally open contact of CR1 at pin 9 through wire 41. The other side of this contact at pin 11 is connected to a normally closed contact on both the motor forward and reverse contactor through wire 44. The other side of the motor forward contact is connected to the motor reverse contactor coil at terminal A1 through wire 46. The other side of motor reverse contact is connected to the motor forward contact at terminal A1 through wire 43. Terminal A2 on the motor forward contactor coil is connected to JP4 pin 2B which is switched to 0 volts dc to turn on the contactor. Terminal 2A on the motor reverse contactor is connected to JP5 pin 2A which is switched to 0 vdc to turn on the contactor.

**Spindle Speed Increase** - This solenoid is energized when the spindle speed requested is greater than the present spindle speed. 24 vdc is supplied to the solenoid from JP5 pin 1B through wire 117. Terminal JP5 pin 2B which is switch to 0 vdc when the solenoid is to be turned on is connected to the coil through wire 118.

**Spindle Speed Decrease** - This solenoid is turned on when the spindle speed requested is less than the present spindle speed. 24 vdc is supplied to the solenoid from JP6 pin 1A through wire 113. Terminal JP6 pin 2A, which is switched to 0 vdc when the solenoid is to be turned on, is connected to the coil through wire 114.

**Spindle Brake** - This solenoid is energized when the spindle motor is turned off and also when the Emergency Stop circuit is activated. 24 vdc is supplied to the solenoid from JP7 pin 1B through wire 115. Terminal JP7 pin 2B is the switched to 0 vdc when the solenoid is to be turned on and is connected to the coil through wire 116.

**Spindle Off Light** - The spindle off light is turned on when the spindle is off and the spindle is safe for the operator. 24 vdc is supplied from JP6 pin 1B to the light through wire 119. Terminal JP6 pin 2B, which is switched to 0 vdc to turn on the light, is connected to the light through wire 120.

**Axis Fault Inputs** - Each axis has a fault line brought back from the amplifier to indicate an inoperable axis. These signals are driven by an open collector transistor which is turn on to ground when the axis is in fault. If the axis is not in fault, the signal will be about 11 vdc on the input to the AUF board. The X-axis fault is connected to the JP11 pin 2A from the amplifier terminal 8 through wire 61. The Y-axis fault is connected to JP11 pin 2B from the amplifier terminal 8 through wire 60. The Z-axis fault is connected to JP10 pin 2A from

the amplifier terminal 8 through wire 59. Ground for these signals is supplied from JP11 pin 3A to terminal 5 on all amplifiers through wire 63.

**Axis Enable** - The axes are enabled when the operator selects Axis Enable at the control console. 24 vdc is supplied from JP11 pin 1A to a normally open contact of CR1 at pin 3 through wire 62. The other side of CR1 pin 1 is connected to pin 7 on all amplifiers through wire 64. Ground is supplied from JP11 pin 3A to terminal 5 on all amplifiers through wire 63. When CR1 is energized, the axes are enabled.

# CHAPTER 6. Axis Drive System

## 6.1 INTRODUCTION

This chapter describes the axis drive system and its relationship to the V2XT machine. Included are descriptions of the motors, the power supply assembly, and the motor drive module assemblies. A section on drive module setup procedure is at the end of this chapter.

## 6.2 OVERVIEW (Figure 6-1)

The V2XT milling machine has three axes under computer control. Each axis has a dc servo motor and a motor drive module. The AXS board is an interface between the motor drive modules and the BMDC board. The BMDC board uses positioning commands to create the drive signal for the motor drive module.

## 6.3 MOTORS (Figure 6-2)

The machine control system uses totally enclosed, non-vented, permanent magnet dc motors. Each servo motor contains a tachometer and an encoder. The output of the tachometer is combined with the input pulses to create the velocity command. The velocity command is used to develop the current command. The current command, along with the control and motor-encoder feedback positioning signals, is used to control the motor operation.

## 6.4 TRANSMISSION AND RESOLUTION

The transmission system translates motor rotation into table (X, Y-axes) motion or vertical spindle motion (Z-axis). The motor drives a precision ballscrew assembly through a 2:1 belt driven reduction, and the resultant linear motion of the

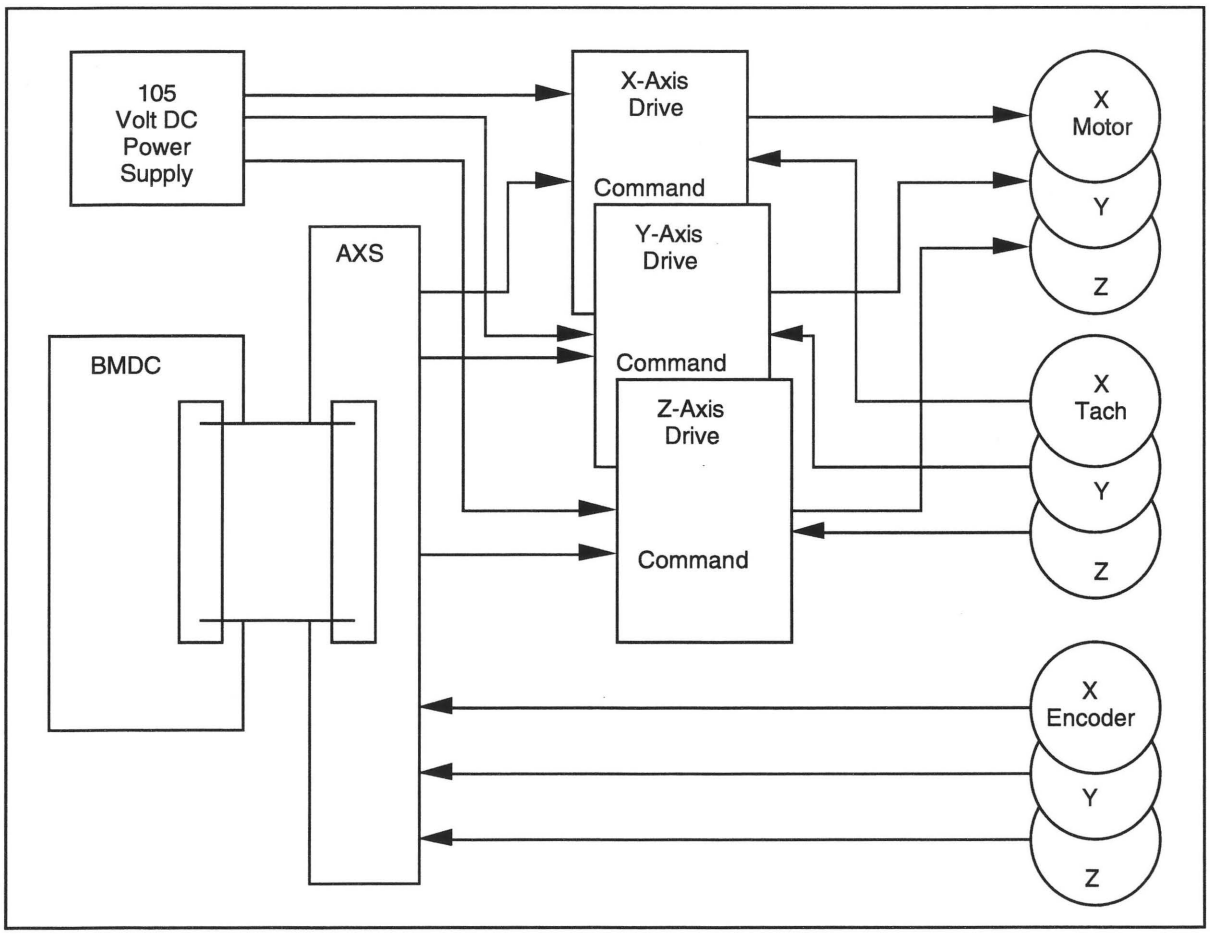
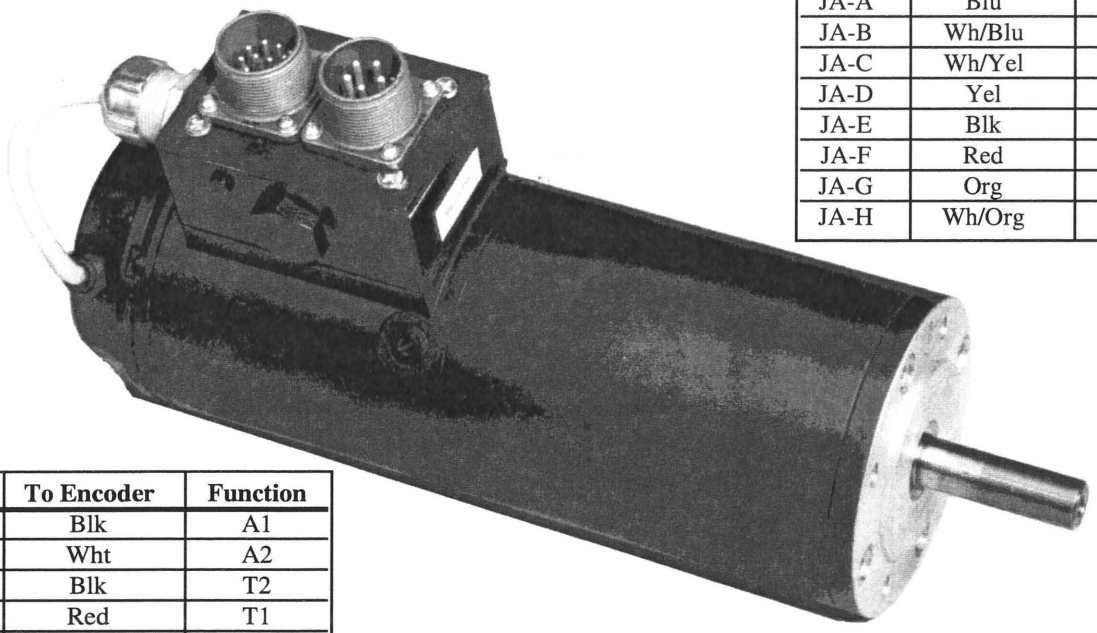



Figure 6-1. Axis Drive - Functional Blocks

# 6. Axis Drive System

| From | To Encoder | Function |
|---|---|---|
| JA-A | Blu | A+ |
| JA-B | Wh/Blu | A- |
| JA-C | Wh/Yel | B+ |
| JA-D | Yel | B- |
| JA-E | Blk | Gnd |
| JA-F | Red | +5VDC |
| JA-G | Org | - Index |
| JA-H | Wh/Org | - Index |



| From | To Encoder | Function |
|---|---|---|
| JB-A | Blk | A1 |
| JB-B | Wht | A2 |
| JB-C | Blk | T2 |
| JB-D | Red | T1 |
| JB-E | Grn | Gnd |

**Figure 6-2.** DC Servo Motor

ballnut relative to the screw causes linear motion of the corresponding axis.

**Calibration.** The combination of 250 encoder lines per revolution of the motor-tachogenerator-encoder shaft, the 2:1 reduction, and a 5-pitch (0.2000 inch per revolution) screw yields and an axis motion of 0.0004 inch per encoder line. The CNC system is accepting this signal in quadrature results in a servo resolution of 0.0001 inch.

**X and Y-Axis Drive Transmission.** The X and Y-axis movements of the table are made by belt-drive conversion of servo motor rotation to the ballscrews. The ballscrews, mounted on precision bearings, rotate with respect to the ballnut. The ballnut brackets are fixed to the table and saddle (Figure 6-3).

The Y-axis servo drive motor is mounted under the knee to protect the operator. The X and Y-axis servo motors transfer motion to the table through timing belts and pulleys at a 2:1 reduction ratio.

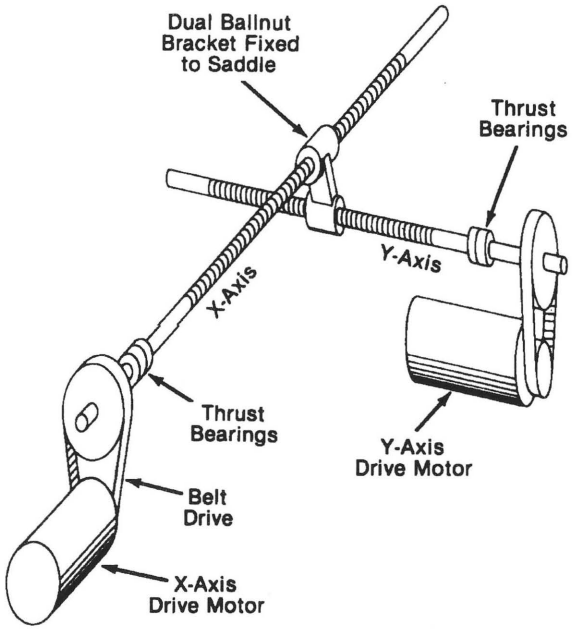



**Figure 6-3.** X and Y-Axis Drive Transmission

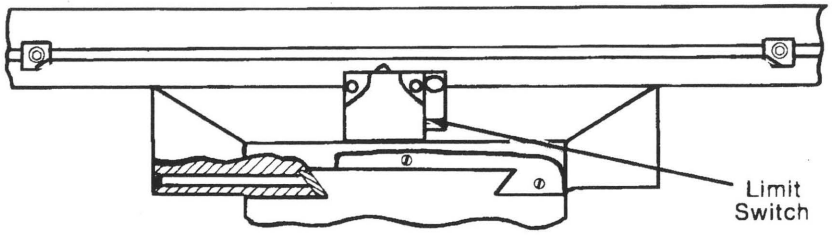



**Figure 6-4.** X-Axis Limit Switch Locations

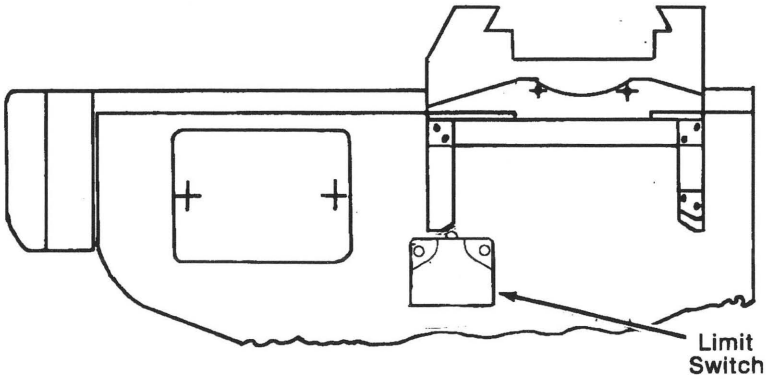



**Figure 6-5.** Y-Axis Limit Switch Locations

**X and Y-Axis Limit Switches**. Lateral table movement beyond software limits is controlled by X-axis electromechanical limit switches. Software control failure or drive malfunction in the saddle is controlled by the Y-axis limit switch. (For X and Y-axis limit switch locations, Refer to Figures 6-4 and 6-5). For proper setting of these switches, see paragraph 10.3.

**Z-Axis Drive**. The quill is powered by a permanent magnet dc servo motor. A timing belt drives the ball quill extension. The ball quill extension has a 0.2000 inch pitch thread carrying a recirculating ball-type nut with a suitable internal preload. With proper adjustment of the timing belt, lost motion is virtually eliminated. The ball quill extension drives the quill through a working travel of 4-59/64 in. (125 mm). See Figure 6-6.

**Z-Axis Limit Switches**. Vertical quill travel is determined by the software limits programmed into

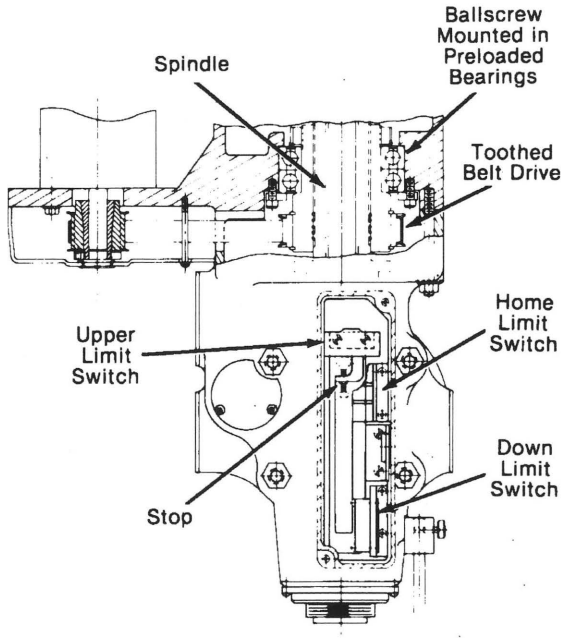



**Figure 6-6.** Z-Axis Drive

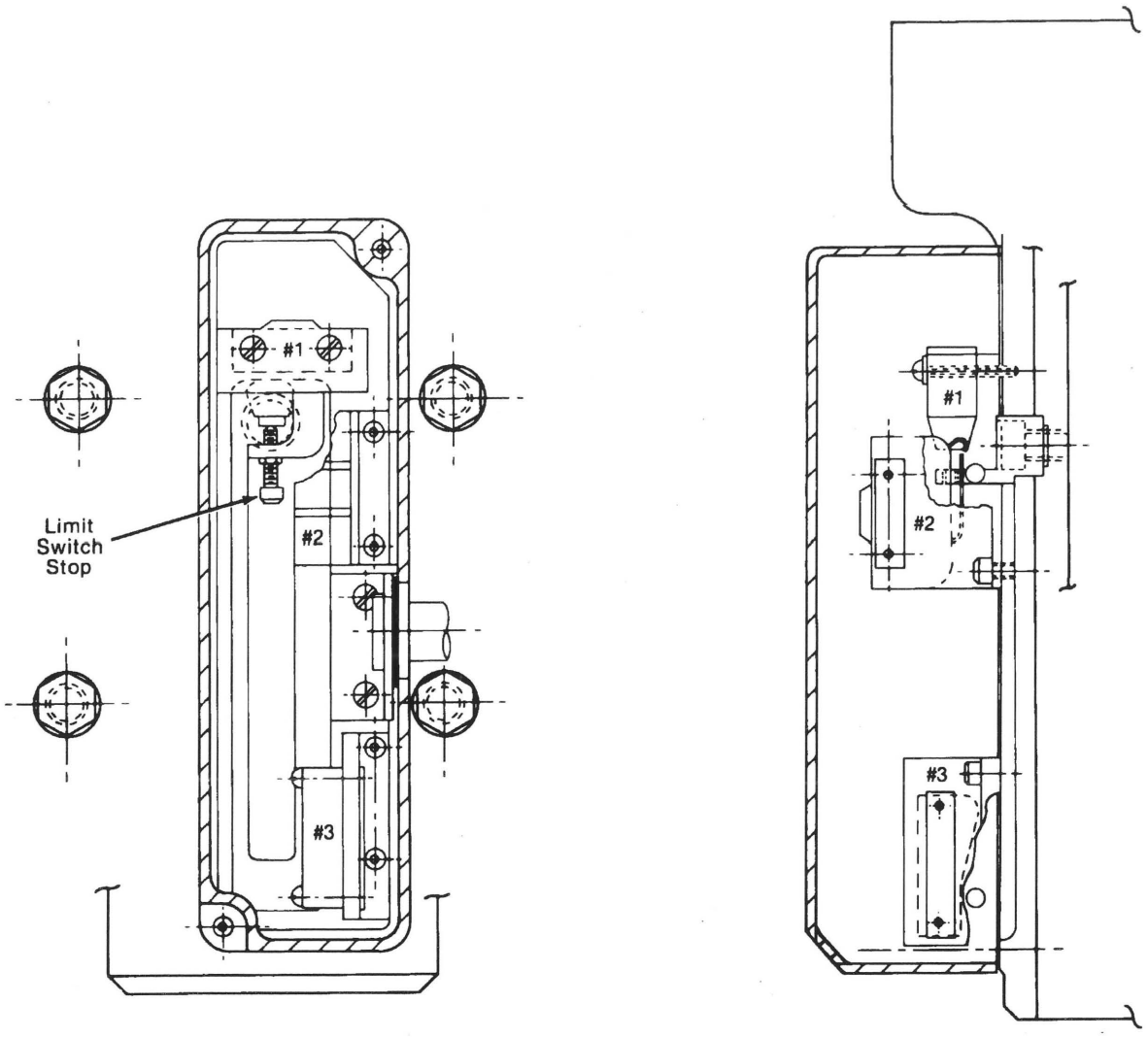



**Figure 6-7.** Z-Axis Limit Switches

the CNC unit. The upper (positive) limits are determined by setting the top limit switch just below the top position switch, Figure 6-7. The lower (negative) limits are determined by measuring full downward travel from the top limit switch and setting the bottom limit switch to actuate at that point. Software limits for operation are then established to fall just short of the limit switch settings. Any software failure or drive malfunction will cause the quill to overrun its normal software limits, tripping the limit switch and shutting down power to the Z-axis drive motor. See paragraph 11.4 for the proper setting of these switches.

## 6.5 POWER SUPPLY ASSEMBLY

**Power Distribution To Power Supplies.** The line voltage comes into the disconnect and fuses 1, 2, and 3. From fuse 1, line 111 is connected to transformer T2 at terminal 1. From fuse 2, line 112 is connected to T2 at terminal H7 for 460 vac or 240 vac and terminal H6 for 208 vac. Refer to schematic 1943101 for the rest of the interconnects for the input of T2 by voltage.

The output of T2 consists of 19 vac between terminals 15 and 16. 115 vac between terminals 11 to 9 and 72 volts between terminals 11 to 10. 115 vac between terminals 12 to 14 and 72 vac between terminals 12 to 13.

The 115 vac terminal 9 is connected to the AUF board at pin 3A on connector JP22 through wire 4. The 0 vac at terminal 11 is connected to the AUF board at JP22 pin 1A through wire 2.

**24 VDC Power Supply.** This supply is used to feed all 24 volt functions. (Refer to the AUF write up in Chapter 5.) The input voltage is 19 vac.

Terminal 15 on T2 is connected to fuse 10 on the input on the 24 volt power supply assembly through wire 8. Terminal 16 is connected to terminal 7 through wire 7. In the power supply assembly, the output of fuse 10 is connected to the ac input of a bridge rectifier BR1. Terminal 7 is connected to the second ac input on BR1. The + output of BR1 is connected to a 2400 mf cap, a 3.3 Kohm resister, and fuse 9 through wire 24. The - output of BR1 is connected to the other side of the 2400 cap, the 3.3 Kohm resister, and the AUF board at connector JP12 pin 2A through wire 39. The output of fuse 9 is connected to the AUF board through wire 40 at connector JP12 pin 1A.

**100 VDC Drive Power Supply**. The output of transformer T2 supplies the power for the 100 vdc drive power supply. Terminal 10 is 72 vac in respect to terminal 11. Terminal 13 is 72 volts in respect to terminal 12. When wired into the electrical circuit, terminals 11 and 12 are tied together with wire 2. Wire 2 is then grounded to chassis and becomes system ground for the complete control. But if the voltage is read between terminal 10 to 13, the voltage is 144 vac. The 72 vac output from ground and terminal 13 is connected to fuse 19 to the input to the 100 Volt Power Supply through wire 3. The other 72 vac from ground and terminal 13 is connected to fuse 20 on the input to the 100 Volt Power Supply through wire 1.

The output of fuse 19 is connected to diode D1 through wire 6. D1 rectifies the positive half of the incoming voltage and charges capacitor C1 through wire 50. Wire 2 is the return path back to the transformer. The output of fuse 20 is connected to diode D2 through wire 5. D2 rectifies the positive half of this voltage and charges C1 through wire 50. Wire 2 returns the current back to the transformer. The positive output of the 100 Volt Power Supply is through wire 50 which is connected to terminal TB2 pin 2 on all drive cards. The ground of the supply is connected to terminal TB2 pin 1 on all drive cards. Fuses 9 and 10 are 25 amp FNW.

**Drive Amplifier Motor Connections.** The power output connections for the X and Y motors is terminal TB2 pin 3 to a normally closed contact on CR4 and to pin B at the motor connector. TB2 pin 4 is connected to a normally open contact on CR4. The other side of the normally open contact on CR4 is connected to a normally closed contact on CR4 and pin A on the motor connector. (Refer to Axis Brake Relay discussion under AUF Outputs for more information on CR4.) Chassis ground is connected to the motor through pin E on the motor connector. In the Z-axis, TB2 pin 3 is connected to a normally closed contact on CR4 and to pin A in the motor connector. TB2 pin 4 is connected to a normally open contact on CR4. The other side of the normally open contact is connected to a normally closed contact on CR4 and pin B on the motor connector.

**Tachometer Connections.** The positive output of the tach is connected from pin C at the motor connector to terminal TB2 pin 4 in the X and Y-axis. The minus output at pin D in the motor connector is connected to pin 3 in TB2. In the Z-axis, the positive tach output at pin C in the motor connector is connected to TB2 pin 3 and the minus output at pin D in the motor connector is connected to TB2 pin 4.

THIS PAGE INTENTIONALLY LEFT BLANK

***HB SERIES***
***MOSFET PWM AMPLIFIERS***
***FOR BRUSH TYPE D.C. SERVO MOTORS***

# USER GUIDE
# SERVO AMPLIFIER

**January 1991 Rev. E**

**MOTION SCIENCE INC.**

**WARNING**

**AVOID HUMAN CONTACT WITH THE POWER CONNECTOR (J2) AND THE HIGH VOLTAGE AREA OF THE AMPLIFIER, P.C. BOARD ANY TIME POWER IS APPLIED. ELECTRICAL SHOCK CAN RESULT!**

**WAIT AT LEAST 3 MINUTES AFTER POWER HAS BEEN TURNED OFF BEFORE CONTACTING THE MOTOR OUTPUT LEADS.**

**DO NOT APPLY POWER WITH UNTERMINATED LEADS ATTACHED TO THE MOTOR OUTPUT TERMINALS ON J2.**

**MHB AMPLIFIERS MUST BE OPERATED IN ENCLOSURES WHERE ACCESS BY PERSONNEL UNFAMILIAR WITH THE WARNINGS CONTAINED IN THIS MANUAL IS RESTRICTED.**

**INCORRECT SERVO PHASING CAN RESULT IN ERRATIC MOTOR MOTION. SERVO PHASING SHOULD BE ESTABLISHED BEFORE MOUNTING THE MOTOR IN THE MECHANISM.**

# 6. Axis Drive System

## Table of Contents


| | | |
|---|---|---|
| **1** | **GENERAL DESCRIPTION** | 6-11 |
| **2** | **HB SERIES MODELS** | 6-11 |
| | 2.1 General Specifications (All Models) | 6-13 |
| | 2.2 Voltage Specifications | 6-13 |
| | 2.3 Current Specifications | 6-13 |
| **3** | **MODEL SELECTION AND MOTOR COMPATIBILITY** | 6-14 |
| | 3.1 Model Selection | 6-14 |
| | 3.1.1 Amplifier Voltage | 6-15 |
| | 3.1.2 Amplifier Current | 6-15 |
| | 3.2 Motor Compatibility | 6-15 |
| **4** | **POWER AND LOGIC CONNECTOR PIN FUNCTIONS** | 6-17 |
| | 4.1 Power Connectors J2 | 6-17 |
| | 4.1.1 J2 Pin Functions | 6-17 |
| | 4.2 Logic Connector J1 | 6-18 |
| | 4.2.1 J1 Pin Functions | 6-18 |
| **5** | **POWER SUPPLY AND TRANSFORMER REQUIREMENTS** | 6-21 |
| **6** | **POWER, ERROR AND CURRENT INDICATORS** | 6-22 |
| **7** | **JUMPER OPTIONS** | 6-22 |
| **8** | **CURRENT GAIN, VELOCITY GAIN AND BALANCE ADJUSTMENTS** | 6-23 |
| | 8.1 Current Gain (CG) Adjustment | 6-24 |
| | 8.2 Velocity Gain (VG) Adjustment | 6-24 |
| | 8.3 Balance Adjustment (BL) | 6-24 |
| **9** | **CURRENT LIMIT ADJUSTMENT AND OPERATION** | 6-25 |
| **10** | **TEST POINTS** | 6-26 |
| **11** | **ERROR CONDITIONS AND SOLUTIONS** | 6-26 |

# 6. Axis Drive System

## List of Illustrations


| | | |
|---|---|---|
| 1 | Servo System Diagram | 6-12 |
| 2 | Trapezoidal Velocity Profile | 6-14 |
| 3 | HB Amplifier P.C. Board Layout | 6-16 |
| 4 | Logic Connector Interface Schematic | 6-20 |
| 5 | Power Supply Circuit | 6-21 |
| 6 | Current Limit Adjustment Graph | 6-25 |

# 6. Axis Drive System

## 1 GENERAL DESCRIPTION

The HB Series Models are MOSFET pulse width modulated switching amplifiers designed to drive dc motors (brush type) in high performance servo systems. HB Series Models cover the power range from 500 Watts to 3 Kilowatts peak. HB models are configurable as either current (transconductance) amplifiers for motor-encoder servos or as velocity control amplifiers for motor-tachometer-encoder servos. The differential H-Bridge configuration provides precise 4 quadrant motor control. HB amplifiers operate at a switching frequency of 22 KHz, which eliminates audible noise and provides high frequency current response. The amplifier power efficiency is typically over 90% because of the low on resistance and minimal switching losses of MOSFET power transistors. External cooling fans are not required for most applications.

HB amplifiers operate on an unregulated single voltage dc supplies and have on board switching logic supplies. External logic supplies are not required. Safety features include motor short protection, over/under voltage protection, and a user adjustable integrating current limiter.

## 2 HB SERIES MODELS

The HB series models have 4 operating voltage ranges that cover from 18 to 160 vdc. HB models have 2 current ranges, the lower range models have peak currents up to 20 amperes and the upper range models have peak currents to 32 amperes. The average (R.M.S.) current limits are configurable from 25% to 67% of peak current. The standard average current limit is 50% of peak current.

| **HB Model** | **Supply Input Voltage Range** (Volts DC) | **Peak Output Current** (Amperes) | **Average Output Current Standard** (Amperes) | **Average Output Current Standard** (Amperes) |
|---|---|---|---|---|
| **HB16032** | 100 TO 160 | 32 | 16 | 21 |
| **HB16020** | 100 TO 160 | 20 | 10 | 14 |
| **HB12032** | 65 TO 120 | 32 | 16 | 21 |
| **HB12020** | 65 TO 120 | 20 | 10 | 14 |
| **HB5032** | 35 TO 70 | 32 | 16 | 21 |
| **HB5020** | 35 TO 70 | 20 | 10 | 14 |
| **HB2432** | 18 TO 36 | 32 | 16 | 21 |
| **HB2420** | 18 TO 36 | 20 | 10 | 14 |
| * May require cooling fan if this mode is selected. Refer to section 9. | | | | |

# 6. Axis Drive System

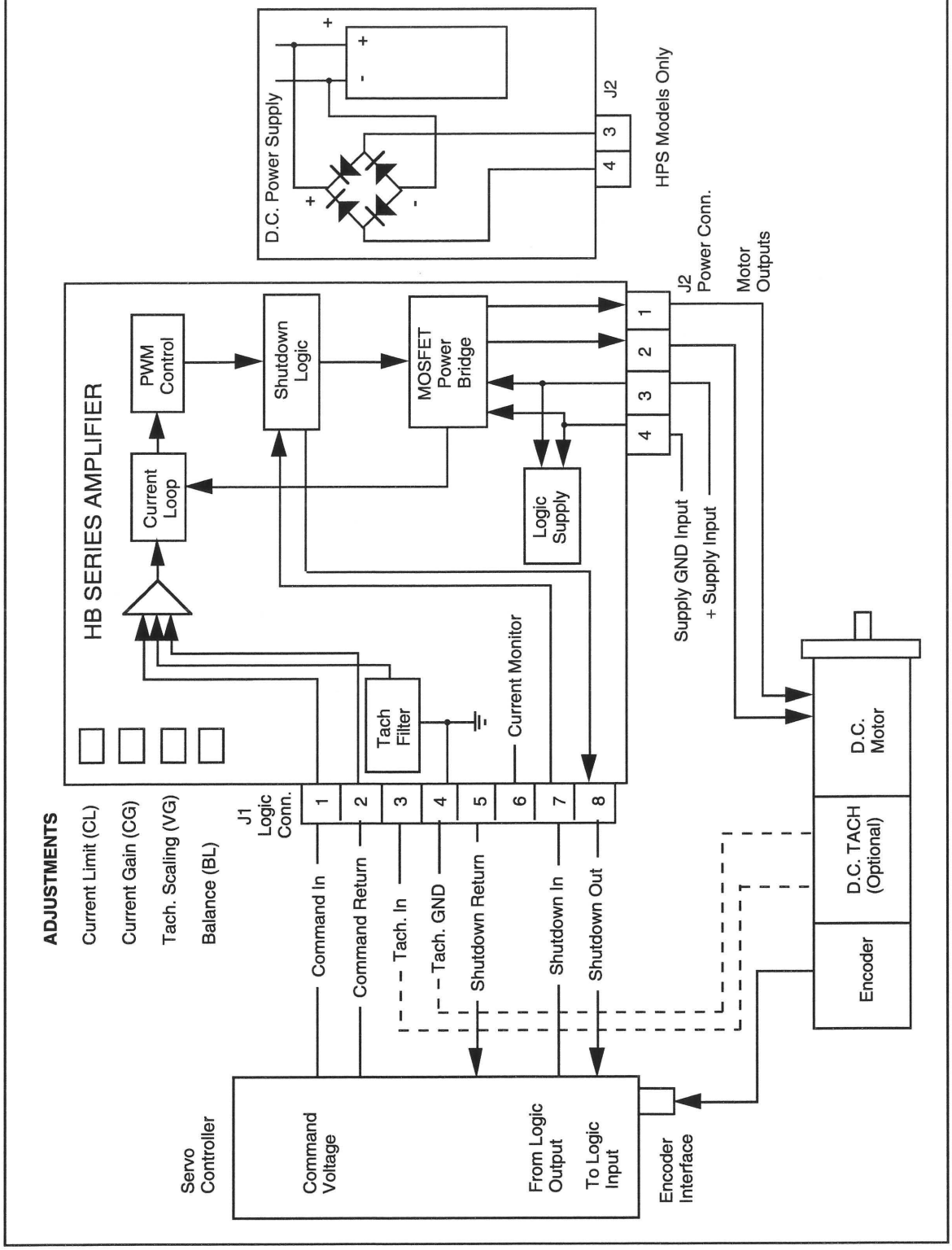



**Figure 1.** Servo System Diagram

# 6. Axis Drive System

## 2.1 General Specifications (All Models)

| | |
|---|---|
| Switching (PWM) Frequency | 22 KHz |
| Maximum Motor Voltage | 97% of the dc Supply Voltage |
| Command Input Format | Differential |
| Maximum Command Voltage | + / - 15 Volts |
| Tachometer Input Format | Single Ended |
| Maximum Tachometer Voltage | + / - 50 Volts |
| Tachometer to Command Scaling Adjustment (VG) Range | 0.4 Volts/Volt to 3.2 Volts/Volt |
| Maximum Shutdown In Voltage | 30 Volts |
| Maximum Shutdown Out Voltage | 30 Volts |
| Minimum Motor Inductance | 1.0 Millihenry |
| Minimum Motor Resistance | 0.25 Ohms |
| Minimum Motor Electrical Time Constant (R/L) | 0.75 Milliseconds |
| Current Loop Bandwidth | 1 KHz (Large Scale) |
| Current Loop Bandwidth | 2 KHz (Small Scale) |
| Current Gain Linearity | + / - 3% |
| Operating Temperature Range | 0 to 60⁰ C (32 to 138⁰ F) |

## 2.2 Voltage Specifications

| **HB Model** | **Minimum Operating Voltage Limit** (Volts dc) | **Maximum Operating Voltage Limit** (Volts dc) |
|---|---|---|
| **HB160XX** | 90 | 178 |
| **HB120XX** | 58 | 130 |
| **HB50XX** | 28 | 74 |
| **HB24XX** | 16 | 38 |

## 2.3 Current Specifications

| **HB Model** | **Peak Current Limiter Range** (Amperes) | **Average Current Limiter Range (Standard)** (Amperes) | **Current Gain Range (JP1 In) CG Adj.** (Amperes/Volts) | **Current Monitor Pk Current Limit Avg. Current Limit Test Point Scaling** (Amperes/Volts) |
|---|---|---|---|---|
| **HBXXX20** | 7.5 > 20 | 3.7 > 10 | 0.6 > 2.4 | 2.0 |
| **HBXXX32** | 15 > 32 | 7.5 > 16 | 1.0 > 4.0 | 4.0 |

## 3 MODEL SELECTION AND MOTOR COMPATIBILITY

### 3.1 Model Selection

The HB amplifier model selected for a servo system must be capable of outputting the peak motor power required when the maximum servo acceleration rate is used to reach maximum servo velocity. Figure 2 illustrates a trapezoidal velocity profile that has a peak power requirement occurring at the end of the acceleration phase. This condition can exist in servo drive quadrant 1 or 4.

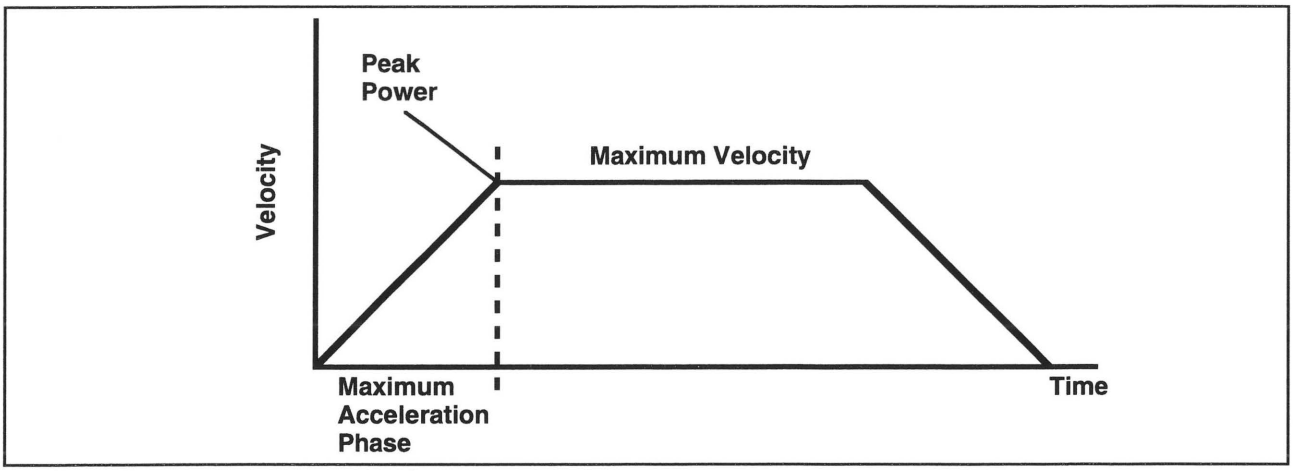



**Figure 2.** Trapezoidal Velocity Profile

The motor voltage necessary to meet the peak power requirement can be calculated as follows:

***Motor Voltage*** = *(Max. Velocity x Motor Ke) + (Peak Current x Motor Resistance)*

The Peak Motor Current required can be calculated as follows:

$$\textit{Peak Motor Current} = \frac{\textit{Peak Servo Torque Required}}{\textit{Motor Kt}}$$

| Equation Parameters | Units |
|---|---|
| **Motor Voltage** | Volts dc |
| **Velocity** | K rpm or Rad./sec. |
| *** Motor Ke (Back EMF)** | Volts/K rpm or Volts/Rad./sec. |
| **Current** | Amperers |
| *** Motor Resistance** | Ohms |
| **Torque** | Oz. in. or Ft. lbs. |
| *** Motor Kt** | Oz. in./Amp or Ft.lbs./amp |
| * Check the Motor Data Sheet for the values of Ke, Kt and Resistance. Kt = Ke x 1.35 | |

### 3.1.1 Amplifier Voltage

An amplifier from the HB Model Chart can be selected using the calculated values for motor voltage and peak current. An amplifier model that operates off a dc supply voltage at least 25% greater than the calculated motor voltage is recommended for the following reasons.

* The output voltage of the amplifier is limited to 97% of the supply input voltage.
* An HB amplifier operating at peak current has an output stage voltage drop of 5 volts at 25 degrees C.
* The motor resistance grows with temperature.
* The output voltage of an unregulated power supply, that is typically used with an HB amplifier, varies with load and ac line voltage.

### 3.1.2 Amplifier Current

The peak current limit rating of the amplifier should exceed the calculated peak current requirement. The average current of the rating of the amplifier is usually determined by the continuous current rating of the motor. Both the peak and average current limits of HB amplifiers are adjustable.

### 3.2 Motor Compatibility

HB Amplifiers are most commonly used to drive laminated rotor (iron core) dc motors that have case diameters from 2 to 6 inches. Moving coil and printed circuit motors have very low inductance and require the use of external series inductors. The electrical time constant of the motor (L/R) must exceed 0.75 milliseconds or a series inductor must be added to increase the time constant. A motor with the rotor inductance in millihenries equal to the rotor resistance in ohms has an electrical time constant of 1 millisecond.

$$Te = \frac{10 \times 10^{-3}\ Henries}{1.0\ ohm}$$

$$Te = 1\ millisecond$$

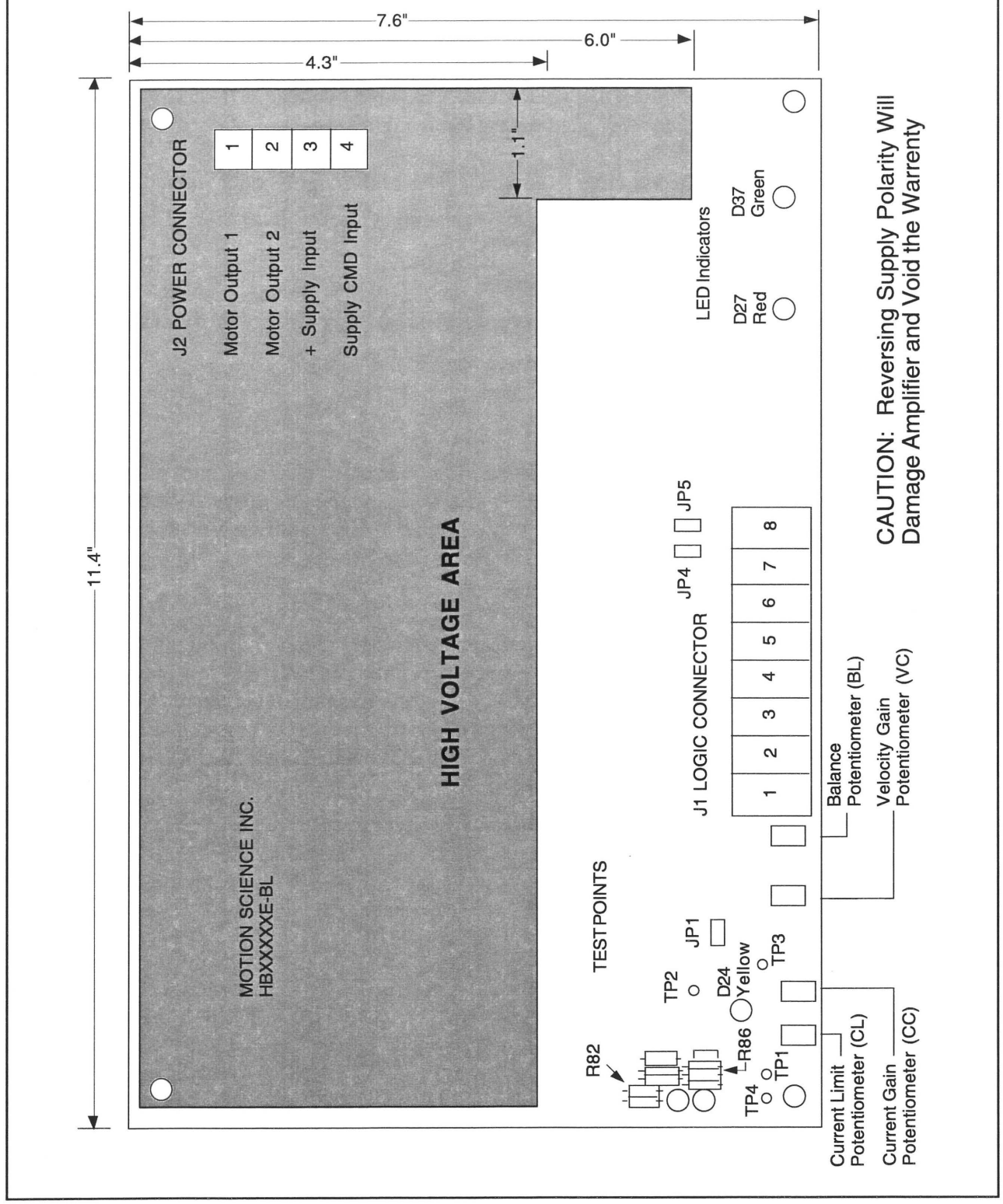



**Figure 3.** HB Amplifier P.C. Board Layout

## 4 POWER AND LOGIC CONNECTOR PIN FUNCTIONS

### 4.1 Power Connector J2

The J2 connector, *Motor Output and Power Supply Input,* is a 4 pin terminal strip, with 7/16 in. spacing and 6-32 Screws.

**WARNING**

Do not connect or disconnect the J2 motor outputs and supply inputs while power is applied. Electrical shock can result!

**CAUTION**

Do not connect the J2 Supply Input (pins 3, 4) to external supply capacitors with large amounts of stored charge present. This will cause excessive surge currents that can produce voltage arching. Excessive surge currents will damage the amplifier fuses, diodes and capacitors.

Correct polarity must be used when connecting the + Supply Input (pin 3) and the Supply Ground Input (pin 4) to external supply capacitors. Incorrect polarity will damage the amplifier fuses, diodes and capacitors and VOID the WARRANTY.

#### 4.1.1 J2 Pin Functions

Pin 1: *Motor Output 1:* Motor Output 1 is a 22 KHz pulse width modulated signal that switches between the supply ground (pin 4) and the + supply voltage (pin 3). This is an output to one of the two dc motor connections. It has (+/-) differential polarity with respect to the J1 Command Input. Output 1 has 50% pulse width modulation when the Command is zero. Output 1 is disabled (high impedance state) if an error condition exists or the J1 Shutdown Input is active.

Pin 2: Motor Output 2: Motor Output 2 is the same as Motor Output 1, except that it switches between the supply ground and the + supply voltage at opposite times in a 22 KHz cycle and has (-/+) differential polarity with respect to the J1 Command Input.

Pin 3: *+ Supply Input:* The + Supply Input is the dc voltage input from the positive output of the external power supply. This input voltage powers the amplifier transistor output stage and the switching level converters used to create the internal logic voltages.

Pin 4: *Supply Gnd Input:* Supply Gnd Input is the ground return for the + Supply Input on pin 3. This is an input from the ground or - output of single voltage external supply.

### 4.2 Logic Connector J1

Logic Connector J1, *Servo Controller and Tachometer Feedback Connector*, is a 8 pin terminal strip with 7/16 inch spacing and 6/32 screws.

#### 4.2.1 J1 Pin Functions

Pin 1: *Command Input:* The Command Input is the analog voltage command from the Servo Controller. This signal regulates either the amplifier output current or the tachometer feedback voltage at pin 3, depending upon Jumper Option JP1. This is typically a bipolar signal, that is scaled by either the CG or VG adjustment so +/- 10 volts equals +/- maximum. The input resistance of pin 1 is 20K Ohms.

Pin 2: *Command Return:* Command Return is the signal return for Command Input (pin 1). It is an input from the Servo Controller command output ground or signal return The input resistance is 20K Ohms.

Pin 3: *Tachometer Feedback Input:* Tachometer Feedback is a bipolar analog input from one of the two tachometer terminals. This input is used in Velocity Mode only and is not connected for Current Mode. Input resistance of pin 3 is 22K Ohms. The scaling of the Tachometer Feedback, with respect to the Command Input, is set with the VG Adjustment.

Pin 4: *Tachometer Ground:* Tachometer Ground is the ground return for pin 3. It is an input from the other Tachometer terminal. This input is not used in Current Mode.

Pin 5: *Shutdown Return*: Shutdown Return is the signal ground return for the Shutdown Input and Output signals on pins 7 and 8. It is an opto-isolated input from the servo controller logic signal ground. It is connected to the Command Return on pin 2 and does not have to be used if the servo controller logic ground is common with the controller command output ground.

Pin 6: *Current Monitor:* Current Monitor is a bipolar analog output signal which is proportional to amplifier output current on J2, pins 1 and 2. This signal is common with test point TP3. The scaling is covered in Section 10, Test Point descriptions.

Pin 7: *Shutdown In:* Shutdown In is a opto-isolated signal that disables the amplifier motor outputs on J2 pins 1 and 2 when it is active. The active condition of Shutdown In is determined by jumper option JP4. This is an input from the servo controller. The opto-isolator is on when more than 1.0 ma flows into pin 7. The input current is limited by an internal 3.3K Ohm resistor. This input is compatible with 5 to 30 volt logic signals that have sufficient sourcing capability.

Pin 8: *Shutdown Out:* Shutdown Out is an opto-isolated signal that is active when the amplifier internal safety logic detects an error condition and the motor outputs are disabled. The active condition of Shutdown Out is determined by jumper option JP5. This is an output to the servo controller or other external equipment and is compatible with 5 to 30 volt logic. The opto-isolator will sink 20 ma with a Vce sat. of 0.8 volts. Shutdown Out will be active for a period of 1.0 second when power is initially applied to J2 (pins 3 and 4).

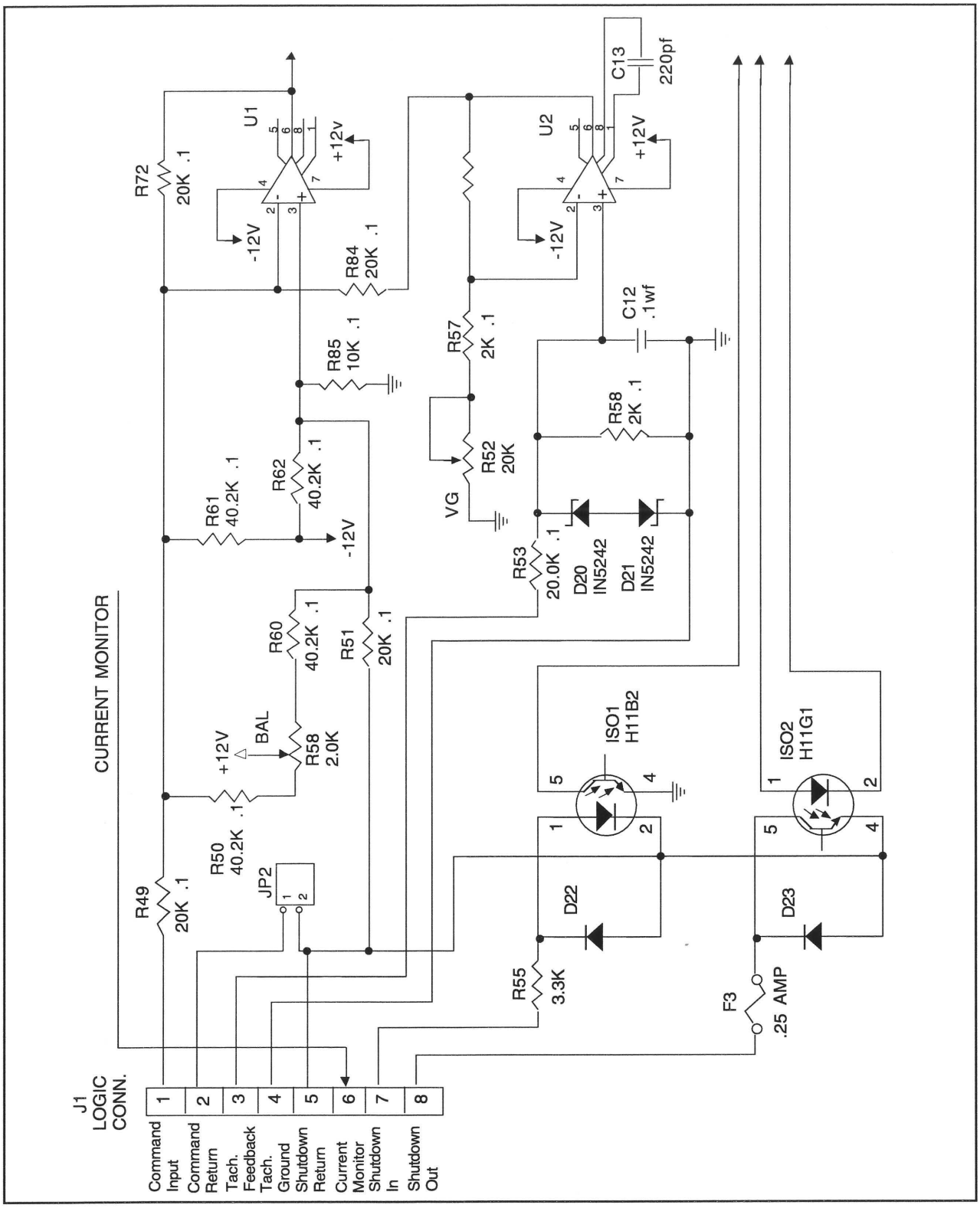



**Figure 4.** Logic Connector Interface Schematic

## 5 POWER SUPPLY AND TRANSFORMER REQUIREMENTS

Board level HB Amplifiers Models operate on unregulated single voltage dc power supplies. The models have wide supply voltage operating ranges and the voltage of the power supply should be sized to meet or exceed the calculations described in Section 3, Model Selection. The supply voltage selected should not exceed the maximum motor terminal voltage. The voltage input at J2 (pin 3 and 4) supplies the transistor output stage and the internal logic supply level converters. The transistor output stage and the level converters are separately fused. The supply for an amplifier typically consists of a ISOLATION transformer, a bridge rectifier and capacitor. This forms a peak rectifier and the dc supply voltage is 1.4 times the ac RMS voltage rating of the transformer secondary. Figure 5 and table following depict a typical supply circuit and the component specifications required to power a single amplifier at full peak current. HB Amplifiers have continuous regenerative effects, that reduce the current loading on the supply. The current draw from the supply approaches the motor current when the motor voltage approaches the supply dc voltage. The HB160XX Models operate off supplies with standard 110/220 to 110 isolation transformer or can be configured to eliminate the need for an isolation transformer.

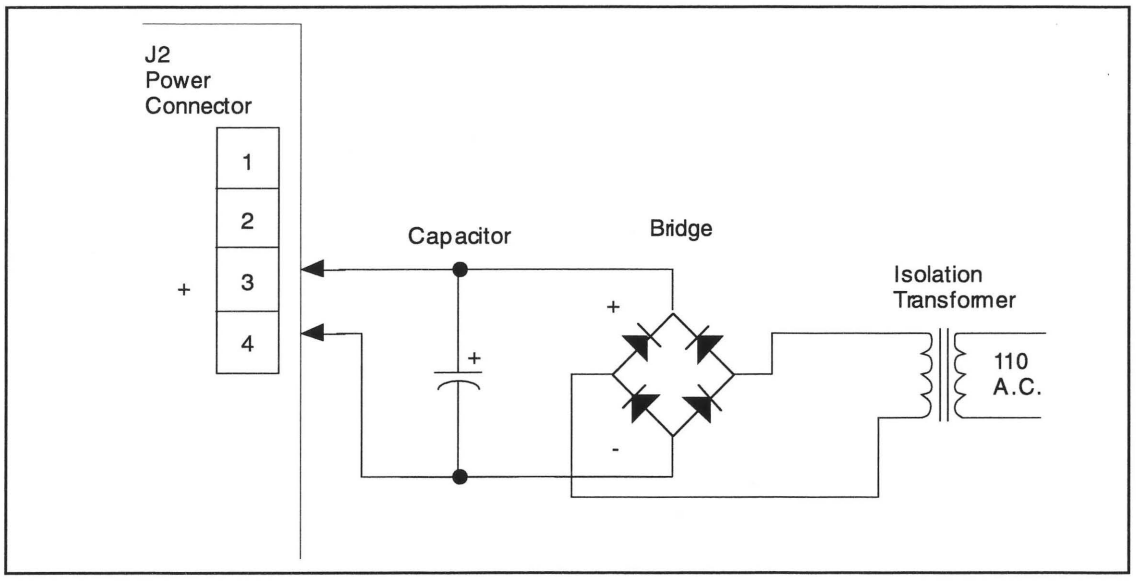



**Figure 5.** Power Supply Circuit

The wires between the supply capacitor and the amplifier J2 connector should be 14 gauge or heavier. The supply capacitor should be located as close to the amplifier P.C. board as possible. Wire lengths longer than 3 feet are not recommended. Multiple amplifiers with the same voltage ratings can be operated off the same supply, provided the supply is capable of outputting the simultaneous current required. The simultaneous current load in a multi-axis application can be much less than the sum of individual amplifier loads, depending on timing between the axial peak power requirements.

| Model | Input Supply Range Volts DC | Transformer Secondary Range Volts AC RMS | Transformer Secondary Current Rating | Minimum Size Supply Cap (uf) |
|---|---|---|---|---|
| **HB16032** | 100 to 160 | 70 to 115 | 25 | 10Kuf |
| **HB16020** | 100 to 160 | 70 to 115 | 16 | 6.8Kuf |
| **HB12032** | 65 to 120 | 45 to 86 | 25 | 10Kuf |
| **HB12020** | 65 to 120 | 45 to 86 | 16 | 6.8Kuf |
| **HB5032** | 35 to 70 | 25 to 50 | 25 | 10Kuf |
| **HB5020** | 35 to 70 | 25 to 50 | 16 | 6.8Kuf |
| **HB2432** | 18 to 36 | 12 to 26 | 25 | 10Kuf |
| **HB2420** | 18 to 36 | 12 to 26 | 16 | 6.8Kuf |

## 6 POWER, ERROR AND CURRENT INDICATORS

Power LED — Color: Green, (Des. # D37)
The Power indicator LED is active when enough voltage is present at the J2 Supply Input to power the amplifier on board logic supplies.

Error LED — Color: Red, (Des. # D27)
The Error indicator LED is active when the J2 Motor Outputs are disabled by an error condition or the Jl Shutdown Input. The Error indicator is active for 1 second when power is initially applied to the amplifier.

Current Limit LED — Color: Yellow, (Des. # D24)
The Current Limit indicator LED is active when the command average output current to the motor exceeds the average current limit adjustment setting.

## 7 JUMPER OPTIONS

Jumper options are used to configure HB amplifiers for either current or velocity model and to define the active conditions of the Shutdown input, output signals. The standard shipping configuration of each jumper option is shown. MOTION SCIENCE will change the jumper options in final test at our plant, if you so request, or if application data has been provided. The locations of the jumper options are depicted in Figure 3, the P.C. board diagram.

**WARNING**

Do not change the jumper options while power is applied. Motor power can be suddenly applied.

| Jumper | Position | Option Description |
|---|---|---|
| JP1 | In (Std.) | Sets the current gain range, CG Adjustment, for transconductance mode. This mode is used with motor-encoder servos that do not have analog tachometer feedback. The voltage at the J1 (pin 1) Command input regulates the differential output current from J2 (pins 1,2). |
| | Out | Sets the current gain range for velocity mode. This mode is used with servos that have analog tachometer feedback. The voltage at the J1 (pin 1) Command input regulates the voltage at the J1 (pin 3) Tachometer feedback input. |
| JP4 | In | Defines the active condition of the J1 (pin 7) Shutdown In signal as a logic low. A logic voltage high signal must be input at pin 7 to enable the amplifier. |
| | Out (Std.) | Defines the active condition of the J1 (pin 7) Shutdown In signal as a logic high. **CAUTION:** The amplifier will be ENABLED after power is applied if a logic voltage high signal is not input at pin 7. |
| JP5 | In (Std.) | Defines the active condition of the J1 (pin 8) Shutdown Out signal as a logic low. The collector output of the shutdown out opto-isolator will close when an error condition is present. |
| | Out | Defines the active condition of the J1 (pin 8) Shutdown Out signal as a logic high. The collector output of the shutdown out opto-isolator will open when an error condition is present. |

### 8 CURRENT GAIN, VELOCITY GAIN AND BALANCE ADJUSTMENTS

The Current Gain (CG). Velocity Gain (VG) and Balance (BL) adjustment potentiometers set the amplifier Command Input (J1, pin 1) scaling and balance. All HB amplifier adjustment potentiometers are 20 turn devices. The locations of the potentiometers are depicted in the P.C. Board Diagram, Figure 3

CAUTION

Turning the CG or VG Potentiometers in the clockwise direction will increase output power to the motor.

MOTION SCIENCE will adjust the potentiometers for the customer application in final test at our plant, if data has been provided.

MOTION SCIENCE will replace the potentiometers with resistors for volume applications with fixed scaling. Current (Transconductance) Mode is used with motor-encoder servos. Current Mode amplifier operation is affected by the CG and BL Adjustments. Velocity Mode is used with servos that

have analog tachometers. Velocity Mode operation is affected by the VG, CG and BL adjustments. Jumper Option JP1 determines which mode has been selected.

> **NOTE**
> The amplifier adjustments will affect the tuning parameters of the servo controller used in the drive system. The amplifier should be adjusted before tuning the controller.

### 8.1 Current Gain (CG) Adjustment

Current Mode: CG sets the scaling between the motor output current from J2 (pins 1, 2) and the Command Input voltage at J1 (pin 1). Clockwise rotation increases the scaling. The adjustment range on HBXXX20 models is from 0.6 to 2.4 ampere/volt, and the range on HBXXX32 models is from 1.0 to 4.0 amperes/volt. The voltage on TP3 is proportional to output current. TP3 scaling is covered in Test Point Descriptions.

Velocity Mode: CG sets the amplifier internal velocity loop gain and clockwise rotation increases the loop gain. The VG adjustment affects CG and VG should be set first when using this mode. The CG adjustment range on HBXXX20 models is from 8.0 to 80 ampere per volt of difference between the Command Input and the Tachometer Feedback Input scaled by VG. The range on HBXXX32 models is from 16 to 160 ampere per volt of difference. CG adjusts damping and affects over-shoot in servos with analog tachometer feedback. HB Amplifier velocity loops have low frequency lag-lead (pole-zero) compensation for stable servo operation at high gain.

### 8.2 Velocity Gain (VG) Adjustment

Current Mode: VG does not affect Current Mode

Velocity Mode: VG sets the voltage scaling between the J1 (pin 3) Tachometer Feedback Input and the J1 (pin 1) Command Input. VG should be adjusted before CG when using this mode. The VG adjustment range on all HB Models is from 0.4 to 3.2 volts of Tachometer Feed-back per volt of Command. Clockwise rotation increases the scaling and the MOTOR VELOCITY. The typical scaling used equates the tachometer voltage generated at maximum servo velocity to 10 volts of Command.

### 8.3 Balance Adjustment (BL)

Current Mode: BL should be adjusted after CG is set. BL should be turned either clockwise or counterclockwise until 0.00 volts appears on the current monitor test point TP3. The Command Input voltage at J1 (pin 1) should be zero when BL is adjusted.

Velocity Mode: BL should be adjusted after VG and CG are set. BL is the Motor velocity balance when this mode is used. The adjustment procedure is the same as Current Mode.

## 9 CURRENT LIMIT ADJUSTMENT AND OPERATION

The Current Limit (CL) Adjustment sets both the peak and average output current limits of the amplifier. The location of the current limit potentiometer is depicted in Figure 3, the P.C. board diagram. The potentiometer is a 20 turn device and clockwise rotation increases both limit settings. This single adjustment can be used to limit the amplifier current capability to protect the motor if a servo controller malfunction occurs. A motor does not have to be connected to adjust CL. The settings of the peak and average current limits can be checked by using the Test Point. See the Test Point descriptions for details. The peak limit adjustment range on HBXXX20 models is from 7.5 to 20 ampere and the range on HBXXX32 models is from 15 to 32 amperes. The standard average limit setting is 50% of the peak adjustment setting. The yellow Current Indicator LED is active when average current limit has been exceeded. Figure 6 depicts the current limit operation of all HB Models.

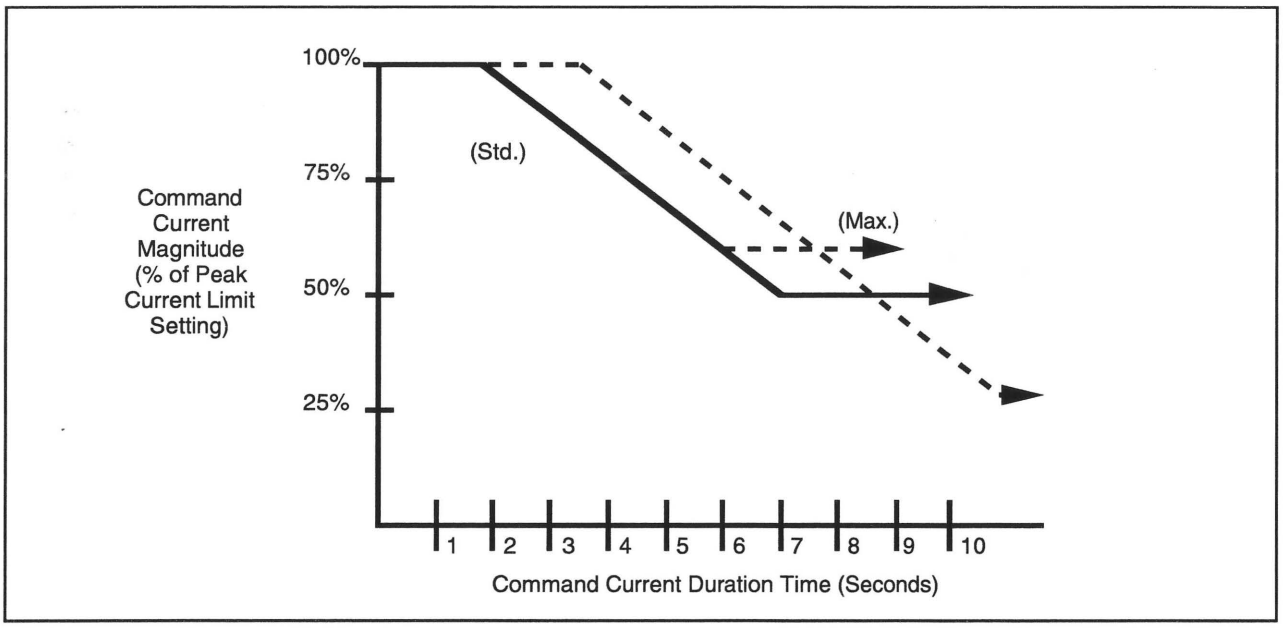



**Figure 6.** Current Limit Adjustment Graph

The average current limit value, as a percentage of the peak setting, is determined by fixed resistor R86. The duration of peak current is determined by fixed resistor R82. **HB amplifiers require fan cooling in heavy duty cycle applications where the CL adjustment is maximum and the average current limit is above 50% of peak or the peak current duration has been extended.** See figure 3, PC. board diagram, for the locations of R86 and R82. Table following shows the value of R86 and the resulting average current limit as a percentage of peak current. The maximum value of R82 and the resulting peak current duration for each average limit setting is also shown. The standard value of R86 is 4.99k Ohms and the standard value of R82 is 390k Ohms.

| R86 (K Ohms) | Average Current Limit (% of PK.) | R82 Maximum Value (K Ohms) | Maximum Peak Current Durations (Seconds) |
|---|---|---|---|
| **2.5** | 67% | 330 | 2 |
| **5.0** | 50% | 680 | 3 |
| **10.0** | 33% | 1000 | 4 |
| **15.0** | 25% | 1500 | 4 |

### 10 TEST POINTS

The signals present on the Test Point pins have voltages proportional to the peak current limit, motor output current, and the average current limit. The locations of the test point pins are depicted in Figure 3, P.C. Board Diagram. An oscilloscope or dc meter can be used to measure the voltages at the pins. The oscilloscope or meter probe ground clip should be isolated from earth ground. Scaling of the TPl, TP3 and TP4 signals is 2.0 amperes per volt on the HBXXX20 Models and 4.0 amperes per volt on the HBXXX32 Models.

| Test Point | Function |
|---|---|
| **TP1** | Peak Current Limit Setting |
| **TP2** | Signal Ground for TP1, TP3, and TP4 Test Points |
| **TP3** | Motor Output Current Monitor |
| **TP4** | Average Current Limit Setting |

### 11 ERROR CONDITIONS AND SOLUTIONS

The error indicator is active when an error condition exists or the Shutdown In signal on J1 (pin 7) is active. See the J1 pin function description for details on the Shutdown In signal.

Error Condition 1: External Power Supply voltage is under the minimum voltage window for the HB Model amplifier.
**Solution:** Increase the power supply transformer voltage or amperage rating.

Error Condition 2: External Power Supply voltage is over the maximum voltage window.
**Solution:** Decrease the power supply transformer voltage rating.

Error Condition 3: Motor Winding short.
**Solution:** Replace the motor or the motor brushes

Error Condition 4: Internal amplifier fault.
**Solution:** Contact Motion Science for repair.

# CHAPTER 7. Troubleshooting

## 7.1 INTRODUCTION

Troubleshooting consists of locating faults by starting with obvious things and moving to the less obvious. Field diagnosis of machine problems can be divided into 2 sets of checks which are listed below. A flow chart, Figure 7-1, is provided to assist in following the steps. The flow chart indicates which subsystem is likely to be at fault, and directs the technician to the proper section in this chapter. Refer to Table 7-1 for Axis Preventive Maintenance Procedures.

### 7.1.1 Procedure

Follow the chart, Figure 7-1, to determine the best place to begin troubleshooting the system. The two major sets of checks are:

1. Incoming Power (Section 7.2.1)
2. Power Supplies (Section 7.2.2)

Additional checks for spindle problems are presented in the Axis Troubleshooting Chart (Table 7-2). Additional information is in Chapter 6 - Axis Drive System.

Use the system wiring diagram to follow the electrical checks and to perform any additional electrical checks if necessary.

## 7.2 ELECTRICAL POWER TEST

Lethal voltages are present in the electrical cabinet, even when the Main Disconnect switch is off. Use extreme caution whenever working in the electrical cabinet. Failure to do so may cause electric shock, resulting in serious personal injury or death.

Power enters the machine at the Main Disconnect switch on the electrical cabinet. Then it is distributed inside the electrical cabinet.

### 7.2.1 Incoming Power

1. The proper ac power voltage is indicated on the label outside of the electrical cabinet. Insure that the correct voltage is supplied to the machine. If not, refer to the System Wiring Diagram for the proper jumper configuration.
2. The incoming power goes directly from the circuit breaker to transformer T1 and T2. Check to insure that 1L1, 1L2, and 1L3 are connected to the terminals that equal the incoming power value, i.e., 230 vac incoming requires that 1L1 and 1L2 be connected to terminals H1 and H3; that terminals H1, H3 be connected to terminals H4, H6 for T1; that 1L3, 1L2 be connected to terminals H1, H7; and that terminals H1, H3 be connected to terminals H5, H7 for T2.

If these wires must be changed, do not move any other wires. They have already been checked for proper installation.

3. Turn on the control and measure the voltage on the input 1L1, 1L2, and 1L3, to transformers T1 and T2.
4. Measure the output voltage from transformers T1 and T2:

T1:

| **Wire No.** | **Machine** |
|---|---|
| X8, X7 | 110 vac |

T2:

| **Wire No.** | **Machine** |
|---|---|
| 2 - 3 | 68-75 vac |
| 2 - 4 | 110-130 vac |

If the output voltage is not correct, repair the connection(s) or replace T1, T2 or as necessary.

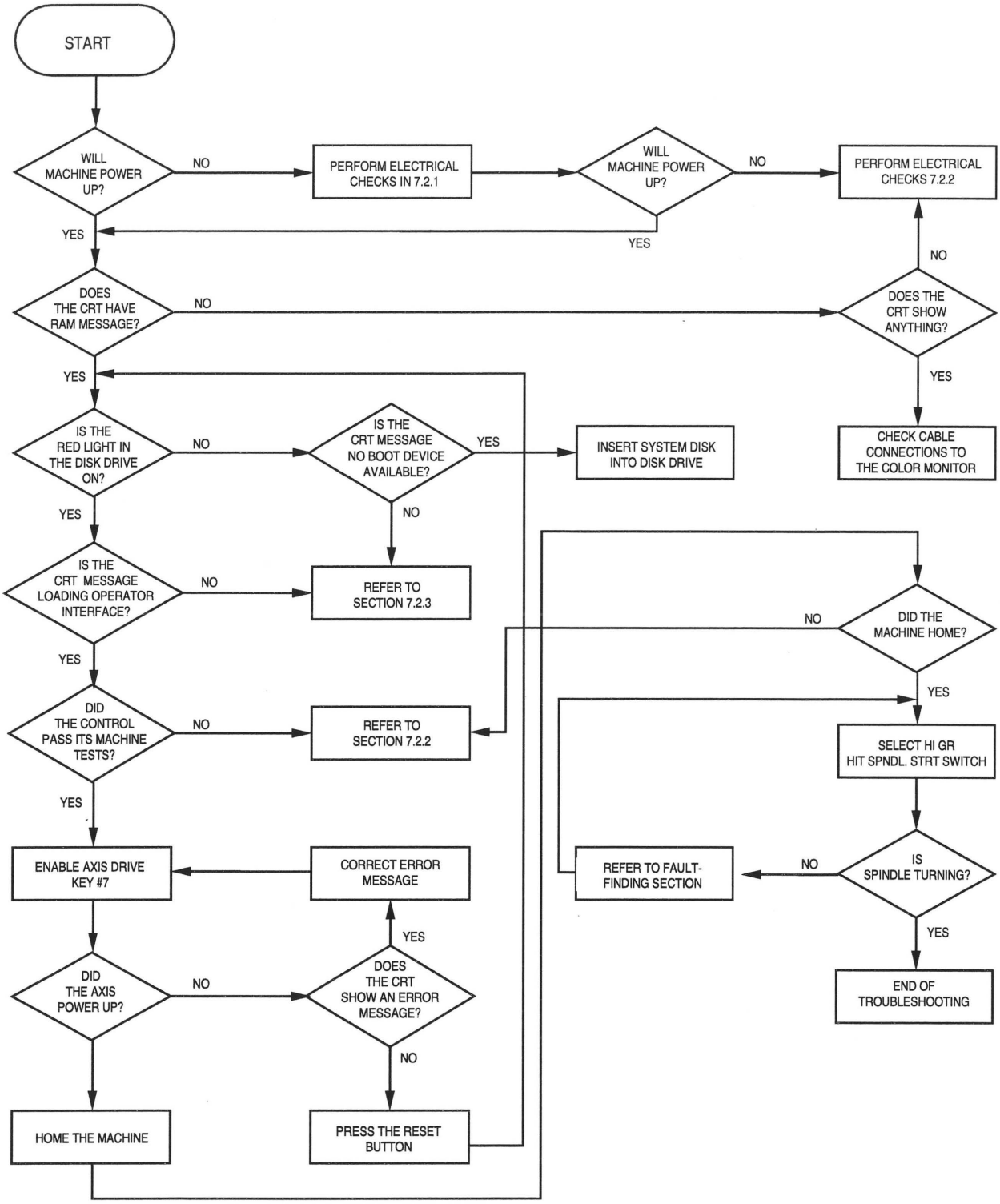



**Figure 7-1.** Troubleshooting Flowchart

# CHAPTER 7. Troubleshooting

**Table 7-1. Axis Preventive Maintenance Procedures**

| Item | Procedure | Time |
|---|---|---|
| Positioning Accuracy | As a normal manufacturing procedure, check the parts made. Check the electrical positioning accuracy and the mechanical machine accuracy. | As Required |
| Voltage Checks | Check voltages listed under 7.2.1, paragraphs 1 through 4 and 7.2.2 paragraph 1. | Semiannual |

**Table 7-2. Axis Troubleshooting Chart**

| Symptom | Possible Cause |
|---|---|
| Power Transistor Failure | The fault sensor is defective.<br>Switching logic is defective on the printed circuit board. |
| Contouring Inaccuracy | Gains of all axes are not identical.<br>There is servo current limiting in contouring speed range. |
| Inadequate Performance | The required accelerating current is not available.<br>There is excessive lost motion such as backlash or windup.<br>There is low frequency mechanical resonance (check by observing open loop response). |
| Position Overshoot | The current limit is too low, or the tachometer gain is too low. |
| Poor Surface Finish | The position loop gain is too high.<br>The tachometer is noisy.<br>There is a defective feedback device or device excitation.<br>A machine drive member is defective.<br>Machine tooling is defective. |
| No Motion (All Axes) | The customer's protective interlocks are set.<br>The main supply fuse is open. |
| Overcurrent Fault (1 Per Axis) | There is an armature circuit fault.<br>The current limit is inoperative or set too high.<br>The armature is shorted to ground. |
| Instability During Power Enable | The position or velocity transducer signal is reversed or the armature wires are reversed.<br>The velocity command is not correct.<br>The position or velocity transducer signal is lost.<br>A printed-circuit board is defective. |
| Instability | The axis is not tuned properly.<br>The position loop gain is too high.<br>The high frequency gain is improperly set.<br>Multiply position loop gains are improperly adjusted (if they are used in the controller). |

Table 7-2. Axis Troubleshooting Chart (Continued)

| Symptom | Possible Cause |
|---|---|
| Instability Manifested by Low Amplitude and/or Low Frequency Oscillation | There is high static to running friction action.<br>Backlash or deadband is present in the machine or transducer. |
| Positioning Accuracy | High friction is present.<br>Position loop gain and/or low frequency gain of velocity loop is low.<br>There is backlash or wind-up in the position transducer/motion connection.<br>The tool reaction forces are too high to be consistent with high accuracy.<br>Pulley is loose on motor shaft.<br>Encoder output not accurate. |
| Positioning Cycle Time Too Long | The final position is overshot.<br>The speed is low.<br>Current limit is set too low. |
| Excessive Machine Wear | Current Limit is set too high or is inoperative.<br>The ripple current in the motor is too high due to noise injected from the transducers. |
| Motor Overheats | The friction level is too high.<br>Current limit is set too high or is inoperative.<br>There is a noise from the transducers that is being injected into the servo.<br>The duty cycle is too severe.<br>The inertia is high.<br>There are high tool reaction forces requiring high motor current.<br>Permanent magnet fields have been demagnetized, causing high armature current to develop torque. |
| Poor Speed Regulation Top Speed | Friction is too high<br>The motor is incapable of operating at the speed being commanded. |
| Axis-to-Axis Speed Interaction | Power supply capacitance is too small, allowing voltage to dip during motor acceleration.<br>Incoming ac line voltage is dipping during acceleration of the motor and allowing the +600 volt bus to drop.<br>High friction of inertia load is pulling the +600 volt bus low.<br>Poor ground connection.<br>The rectifiers are bad or there is some other problem causing the rectification in the power supply to be half wave rather than full wave, creating a low voltage +600 volt bus under load. |
| Erratic Motor Operation | Noise is manifested in the motor current introduced into the servo by transducers.<br>There is poor grounding or there are loose connections.<br>There is a jump on startup or shutdown due to improper interfacing. |

### 7.2.2 Power Supplies

1. This system has a 24 vdc power supply to check. Measure the following voltages:

| Wire No. | Voltage | Location |
|---|---|---|
| 7 to 8 | 19 vac +/- 2V | FU10 |
| 40 to 39 | 24 vdc +/- 2V | FU9 |

2. Check Wires 50 to 2 for 105 vdc, +/-5 vdc, for the motor drives.

3. To check the voltages to the AUF card, make make the following readings:

| Terminals | Voltage |
|---|---|
| JP22-3A to JP22-1A | 115 vac +/- 7.5 vac |
| JP12-1A to JP12-2A | 24 vdc +/- 2 vdc |

The power to the BMDC comes from the 486 card. The AUXBOB, and the AXSBOB cards receive their power through the 50 pin cable that connects them to the BMDC.

### 7.2.3 DX 32 Power System

1. The DX power supply supplies positive 12 volts, 5 volts and negative 12 volts to the 486 board through connectors P8 and P9. They plug into connectors PS1 and PS2 on the 386/486 board.

**CAUTION**

If it is necessary to install P8 and P9 for any reason, INSURE that the black wires on each connector are next to each other, and that the red wires are on the end toward the bottom of the cabinet on PS1 & PS2 pins 10, 11, and 12.

2. To read the voltage from the power supply, measure all voltages with respect to the black wires, ground.

| Connector | Reading |
|---|---|
| PS1, PS2 Pins 5, 6, 7, or 8 to Pin 10, 11, 12 | +5 Volts |
| PS1, PS2 Pins 5, 6, 7, or 8 to Pin 9 | -5 Volts |
| PS1, PS2 Pins 5, 6, 7, or 8 to Pin 4 | -12 Volts |
| PS1, PS2 Pins 5, 6, 7, or 8 to Pin 3 | +12 Volts |

3. The DX power supply also supplies power to the floppy disk drive. Locate J2 and read the following voltages:

| Connector (Wire) | Reading |
|---|---|
| Red to Black | +5 vdc |
| Yellow to Black | +12 vdc |

4. If there is no voltage from the DX power supply, check the 115 vac on the input at wires 10 and 11. This supply also has an internal 5 amp fuse on the card. Check to insure that the fuse is in good working order.

**NOTE**

The power supply will not work without a load on the +vdc pins.

5. The color monitor (CRT) in the front panel is self-contained; the only supply voltage is 115 vac on the power cord at the backing of the unit. If this voltage is present and the CRT is still black, check to insure that the power OFF-ON switch is in the ON position. Also, this unit contains a 3 amp fuse on the 115 vac line. Check to insure that the fuse is in good working order.

6. Troubleshooting suggestions:

| Problem | Checks to make |
|---|---|
| Color monitor is dead | 1. Check voltages<br>2. Check power-on switch.<br>3. Check fuses.<br>4. Check power cord.<br>5. Insure brightness thumb wheel is turned up. |

| | |
|---|---|
| Color monitor has Raster but no video | 1. Check the 386/486 Card for power<br>2. Check that video cable is plugged into monitor and into the 386/486 card (J21). |
| Color monitor is dark | 1. Adjust the brightness control |
| Color monitor will not synchronize | 1. Adjust the horizontal or vertical hold control |
| Color monitor display message<br>NO BOOT DEVICE AVAILABLE.<br>OPERATING SYSTEM MISSING | 1. Check voltage on the floppy disk drive.<br>2. No system disk in the drive unit (if booting from floppy).<br>3. Check C drive<br>4. Check the signal cable from the 386/486 board. |

**DIAGNOSTICS AND PARAMETER FILES**
The V2XT/EXPLORER control is equipped with a set of real-time diagnostics that run in the background. When a diagnostic test discovers a violation of operation limits, it stops the control and posts a message to the operator. The parameter files are used to set the limits for these tests and to describe to the software the function of the machine in which the software is installed.

**PFM PROGRAM -** The Parameter File Maintenance (PFM) program is designed to enable the editing of the parameter file in a more intelligent manner. The actual numbers in the parameter file appear in different machine units for most parameters and must be translated to more recognizable units. The PFM program consists of two separate programs. They are the Parameter Editor and the Tuner program.

**CAUTION**

The file that the Parameter Editor changes is unique to the machine in which it is installed. This file is BMDCPRMS.SYS. To maintain a copy of the original numbers, either copy the file to a floppy disc or make a copy on the hard disk renamed to something like *.OLD.

To get to use the PFM program, page the control back to the Basic Menu window. Select button 9 (DOS). The message window will display "Exit to DOS? <Y> to exit". Type Y. A DOS prompt will appear (C:\>). Type PFM <enter>. The control will load the PFM program into the 386/486 PC board. A dialog box will appears as shown below.

```
Please Select One
Exit Program
Parameter Editor
Tuner
```

While in PFM, each editor program will present a window that will enable the user to accomplish a different task. Within that window will be a dialog box that has specific instructions on how to use that window. The title of this box is "What To Do Now." In this case, the box will have the following instructions. Use UP and DOWN arrow keys to select, the ENTER key to choose, or the ESC key to exit. Arrow down to Parameter Editor and Enter.

**NOTE**

The Escape (ESC) key will allow the exit from most windows.

**PARAMETER EDITOR -**The parameter editor is used to install or modify numbers in the parameter file. This file is established and installed at the time that the machine is built. Modification of any parameter in this file in the field should be done only after consulting the factory.

On entering this editor, a series of dialog boxes will be displayed to the user. A recreation of these boxes appears below.

| Parameter File Window: Center Line Is Current Parameter |
|---|
| 00000000 ; Previous Parameter |
| 00000001 ; Current Parameter |
| 00000002 ; Next Parameter |

| Information About Currently Selected Parameter<br>Three lines of help specific to the parameter that is being edited will appear here. |
|---|

| New Value<br>What You Type In |
|---|

| What To Do Now<br>Two Line of General Information about what to do now: edit field , choose from list, etc. |
|---|

| General Instructions<br>Hit any Key to Begin Editing Parameters. |
|---|

When a key is hit, a new dialog box appears as shown:

| Please Select One |
|---|
| Exit Param Editor |
| Edit Param File |
| Edit Machine Params |

The Exit Param Editor returns the user to the first page. The Edit Param File will change the stored file and the present operating file but restricts the use of the "read only" parameters. Edit Machine Params will change the operating parameters in the machine immediately and permit the examination of parameters above 149 in real time. These parameters include switch closures and machine commands (refer to the parameter listing at the end of this chapter).

Select Edit Machine Params file and Enter. The parameter file window now displays new numbers and the parameter numbers can now be modified. The window will be displayed as shown below.

| Parameter File Window: Center Line is Current Selection |
|---|
| 00000001693 ; #1 Low Speed (below breakpoint) Acceleration |
| 00000001693 ; #2 High Speed (above breakpoint) Acceleration |
| 00000050969 ; #3 Acceleration breakpoint |

Note that the 11 digit number now represents a parameter in machine units, and without a working knowledge of the machine software and its use in the software, the number is unintelligible. Also, the current parameter will be highlighted. To go to the edit mode, select a parameter and press Enter. In the case of parameter #2, the New Value and the Information About the Current Parameter, and the What To Do Next box change:

| New Value<br>9.998031 |
|---|

The What To Do Next box is

| What To Do Next<br>Enter New Value in INCHES PER MINUTE |
|---|

The Information About Current Parameter box displays a brief description about the parameter. (Refer to the parameter file listing at the end of the paragraph for the text that will be displaced for parameter #2.)

The New Value box can now be modified. When Enter is pressed, the new value becomes active.

After the new values and the parameters are determined to be acceptable, the parameters can be saved by pressing ESC. A new dialog box will appear as shown below.

| Please Select One |
| --- |
| NO-Discard Changes |
| YES-Update File |

About the two selections: "NO-Discard Changes" discards any changes made; "YES-Update File" writes the changes to the stored parameter file where they will be used until they are again updated.

**READ ONLY PARAMETERS** - The V2XT/EXPLORER machine is equipped with a set of parameters that can be useful for checking switch closures and commands to start functions assigned to the machine. These parameters start at parameter #150 and go up to parameter #172. To view these parameters, enter Edit Machine Params. Page up to the desired parameter or press G followed by the parameter number and press Enter. The Information About Currently Selected Parameter window will display a listing of the number that appears in the New Value window. Below is an example of these windows for parameter #164.

| Information About Currently Selected Parameter |
| --- |
| Spindle Status Word |
| PN,HG,LG,SB,AS,ZS,SR where : PN=Pin, HG= HiGr, LG=LoGr SB=Spindle Brake, SH=Spindle Home, AS=At Speed, ZS=Zero Speed, SR=Spindle Ready. |

The New Value dialog box will be as shown.

| New Value |
| --- |
| 00000000 |

The digits in this box are real-time and are updated when a change in their status occurs. The digits correspond to the function as described in the Information About Currently Selected Parameter window.

The What To Do Window will be as shown.

| What To Do Now |
| --- |
| Live (non-Editable) |
| Read-Only Parameter |

**LEADSCREW COMPENSATION** - The V2XT/EXPLORER machine has one set of parameters for compensating the inaccuracy of the leadscrew on each axis. The leadscrew compensation is a linear adjustment that is prorated across the length of travel. The inaccuracy of the leadscrew is established by reading from the 0 position to the end of maximum travel of the axis to determine the actual distance traveled The formula for calculating the input number is Leadcomp = (ideal resolution X Ideal distance divided by Real distance) - Ideal resolution) X 65536.

Example:
Assume ideal res is 50 cums (para 32 through 36)
Assume ideal dist is 20 inches
Assume measured dist is 19.999 inches
Leadcomp = ((50 X 20" /19.999") - 50) X 65536
Leadcomp = 163.848
Round out this value to 164 and install in the correct parameter 105 through 108.

**The TUNER PROGRAM** - This program was designed to aid in setting up the machine at factory start up. This program can be useful in testing the performance of the control in the field.

To load the TUNER program, enter the PFM program as described at the beginning of this paragraph. When the following dialog box appears, page down to highlight the TUNER selection and press Enter.The TUNER program will be loaded into the 486 PC where it will supervise the performance of the BMDC in real-time.

| Please Select One |
| --- |
| Exit Program |
| Parameter Editor |
| Tuner |

The Tuner is pictured on the top of the next page.

| | POS | POS-ERR | DAC-CMD | DAC-OFF | HOME-SW | Feed Cmd: 0.0000 |
|---|---|---|---|---|---|---|
| X-axis | 0.0001 | 0.0000 | 00000 | 00000 | OFF | Feed Ovr: 200% |
| Y-axis | 0.0000 | 0.0000 | 00000 | 00000 | ON | Feed Act: 0.0000 |
| Z-axis | 0.0002 | 0.0000 | 00000 | 00000 | OFF | |
| C-axis | 0.0000 | 0.0000 | 00000 | 00000 | | RPM Cmd: 0.0000 |
| S-axis | 0.0000 | 0.0000 | | 00000 | 00000 | RPM Ovr: 100% |
| | | | | | | RPM Act: 0.0000 |
| Prev: | | | | | TL: 0.00 | Load: 001% |
| Cur: | | | | | TD: 0.00 | |
| Next: | | | | | 000:00:00 | MOVE: *DONE* |

| | | | |
|---|---|---|---|
| F1:Event Log | F2:Backlash | F3:LeadComp | F4:Position:DES |
| F5:ABS / INC: ABS | F6:Inch / MM: IN | F7:Drives:OFF | F8:Home X,Y |
| F9:Enter Move | F10:Enter Offsets | 1:MDI | 2:Load program |
| 3:Reset Program | 4:Mode: Setup | 5:Cycle Start | 6:Reset Alm Alarm |
| | | 8: Set Jog | |

```
BMDC version 6.20 running
reading param file....
File Version is 3.20
setting 149 params....
done setting parameters.
Loading leadcomp file....
Done loading Multi-Point Compensation Tables
```

The continued dialog is an explanation of that display.

The first column to the top left of the display describes the axis to which the information applies. The headers at the top are as follows: POS is the commanded position; POS-ERR is the difference from Actual Position and Commanded Position; DAC-CMD is the actual digital number that is presented to the digital to analog converter; DAC-OFF is the amount of DAC offset, and HOME-SW is the state of the home switches.

The **POS** column can be used to determine the command for the axis motion. This column is updated by the encoder on the motor of each axis. Before the machine is homed but with the drives in OFF, turn the motor shaft to have POS count the pulses. After the drives are on and the machine is homed, select 8 and enter an axis to jog.The manual jog will update the POS column as it is jogged. The display is 0.0001 inch resolution.

**POS-ERR** can be used to determine the difference between actual and commanded position. This column is dynamic and can be used to determine the following error during acceleration and constant velocity of an axis. This column is used for matching the following error on the X- and Y-axis during the FERROR program. Also matching the S-axis and Z-axis following error during the coordinated tapping cycle is another example. The unit for this column is 0.0001 inches.

**NOTE**

On this page the BMDC software and the Parameter file version can be found. The parameter file is modified to suit the

characteristics of the machine at time of startup. Therefore, each parameter file is different from the next machine. The characterization of this file does not change the software version found on the display. The version number applies to the software in which the parameters are contained.

**DAC-CMD** is used to balance the axis drive offset when the axis in position. The display should be adjusted to read 0.0000 with the axis balance pot. The DAC have a range of +/- 2048 which is equal to +/- 10 Volts.

**DAC-OFF** is little used in the field. It is the offset required to hold a motor at zero.

**HOME-SW** displays the status of the home switches. The first use of this display is to assure that the switches are working. The second use is to set the distance from home to the switch. To set the switch accurately, it is important to determine the amount of travel for 3/4 of a revolution on the motor. Example: on an 8 mm leadscrew geared 2:1 to the motor, 1 revolution of the motor is 4 mm. 3/4 of 1 revolution is 3 mm. To set the switch correctly, press F4, which will switch the display from inches to metric. Home the machine. If the position display is anything but 0.000, press F10. Enter 0.000 into the axis display to be checked. (Refer to F10:Entering Offsets later in this chapter) Now jog the axis off the switch and slowly back on to it with the Jog Knob. When the switch changes state to On, the readout should read 3 MM +/-.01. If the readout is not within this range, set the readout for 3 MM and adjust the switch to close at this point. Again, back off the switch and check the distance to home.

**FEED CMD** is the commanded feed rate for a given move in the G01,02, 0r 03 mode.

**FEED OVR** is the amount of feed rate override in effect for the move.

**FEED ACT** is the actual feed rate used for a commanded move. Actual feedrate is the commanded feedrate times the feed-rate override times vectorial velocity.

**RPM CMD** is the commanded spindle RPM.

**RPM OVR** is the amount of spindle RPM override being used.

**RPM ACT** is the actual spindle RPM commanded. RPM Actual is the RPM commanded times the RPM override.

**LOAD** is the percentage of 7.5 horsepower being generated by the spindle motor.

**PREV** is the previous line of information commanded by the part program.

**CUR** is the current line on information commanded by the part program.

**NEXT** is the next line of part program to be acted on by the control.

**TL** is the tool length being used by the tool number in the spindle.

**TD** is the tool diameter called from by the tool table for the tool in the spindle.

| | | | | |
|---|---|---|---|---|
| Enter LeadComp | ( "*" = no change) | | | |
| X: Expected : | 18.0000 | Measured | 18.0000 | INCHES |
| Y: Expected : | 12.0000 | Measured | 12.0000 | INCHES |
| Z: Expected : | 15.0000 | Measured | 14.0000 | INCHES |
| C: Expected : | 17179.869180 | Measured | 17179.869180 | DEGREES |

**000:00:00** is time to the second.

**MOVE: *DONE*** is the status of the control. If a move is being processed, the status is Active. In the Jog Mode the control is always active because the Jog handwheel is always capable of moving the selected axis. If a move is not complete, the done status will never come on. This state could exist if the servo gains were low or the In Position window was too small.

F1: **Event Log** is a storage space for 16 events that affect the performance of the control. An example is any error that causes emergency stop or tool change time. This log is erased when the machine is shut off.

F2: **Backlash** is a method to enter backlash compensation into the machine.
The window is:

| Enter Backlash ("*" = no change) | | |
|---|---|---|
| X: | 0.0000 | inches |
| Y | 0.0000 | inches |
| Z: | 0.0000 | inches |
| C: | 0.0000 | inches |

The number entered in here is stored in parameters #55 through #59.

F3: **LeadComp** is a simplified method to activate the linear leadscrew compensation parameter. (Refer to the display that is pictured on the previous page.) The entries inserted into the dialog box are converted by the formula described above and entered into the appropriate parameter for that axis (#105 through #108). The dialog box will request two entries for each axis to be compensated. They are the expected dimension which is generally the distance for total travel on that axis and the measured distance for that travel. When entering numbers into this box, use the asterisk key to pass an axis that should not be changed. Pressing an enter to skip an axis will enter a zero.

F4: **Position** changes the POS display on the top left on the CRT screen from Desired to Actual position. It will toggle each time the F4 button is pressed.

F5: **ABS / INC** will toggle the control from absolute to incremental mode. This status will affect the manual move information input into the control.

F6: **Inch / MM** will toggle the control from inches to metric with each stroke. The display will change from 4 digits to the right of the decimal for inches to 3 digits for metric.

F7: **Drives** will toggle the power to the axis motors on and off with each stroke. The control will compensate for the appropriate functions when this key is used. Example: the Z brake will turn on and off with the drives.

F8: **Home** will home all axes and the toolchanger if it is present.

F9: **Enter Move** will present a dialog box that will enable many possible moves to be entered. The dialog box is shown below.

| Enter Move | | |
|---|---|---|
| Mach, Usr Coords 0,1=Move 2,3=Jog | | |
| Taper 4-9=JogArc: 0 | | |
| X: | 0.0000 | INCHES |
| Y | 0.0000 | INCHES |
| Z | 0.0000 | INCHES |
| C: | 0.00000 | DEGREES |

The move mode is selected as follows.

0 Move in machine coordinates.
1 Move in user coordinates.
2 Jog-Taper in machine coordinates.
3 Jog-taper in user coordinates.
4 Jog-arc in machine coordinates on the X and Y plane.
5 Jog-Arc in user coordinates on the X and Y plane.

6 Jog-Arc in machine coordinated in the X and Z plane.
7 Jog-Arc in user coordinates in the X and Z plane
8 Jog-Arc in machine coordinates in the Y and Z plane
9 Jog-Arc in user coordinates in the Y and Z plane.

F10: **Enter Offsets** will present a dialog box as shown below.

```
Enter Offsets ( "*" = no change )
    Coord System (0=Base 1=user) : 0
    X:          0.0000          INCHES
    Y:          0.0000          INCHES
    Z           0.0000          INCHES
    C:          0.0000          INCHES
    S:          0.0000          INCHES
```

**CAUTION**

Base coordinates are installed when the machine is homed. Care must be taken when entering information into these offsets. The default is set to BASE coordinate system. If any inputs are made in the base system, the machine is permitted to operate within the software limits but the base reference has been moved. The result is that the axis can exceed the mechanical limits in a rapid rate. To recover, reset the machine and reload the control software. To use the USER coordinates, enter a 1 for the coordinate system. The user can now preset the POS display to read the number entered into the appropriate axis. Example: if an axis has 20 inches of travel and the axis is at home when the user system coordinates are changed to read -5 inches, the control will operate from the readout position of -5 inches to -25 inches. If the coordinates were changed to plus 5 inches, the machine would operate between 5 inches and -15 inches. A command of axis "0" will be -5 inches from home.

1: **MDI** permits a manual move to be entered a line at a time.

2: **Load program** generates a dialog box that permits the user to type in a title of a part program to be loaded to the BMDC for execution when the control is in auto and cycle start is requested.

3: **Reset Program** readies the control to start operation from the beginning of a stored part program on the BMDC.

4: **Mode** will change the function of the control as requested. The following dialog box will be displayed.

```
                Select Mode
<S>etup,<B>lock,<A>uto,<P>c,Pre<V>iew:
```

**Setup** mode is used for most non-programmed operations.

**Block** mode is used to execute one G Code statement at a time.

**Auto** places the control in a mode that initiates an auto-run when cycle start is commanded.

**PC** is a special function that permits the PC software to issue a sequence of commands to the BMDC, as in the probing mode.

**PreView** is a mode where the part program on the BMDC is parsed a line at a time to the front end when the front end requests it for graph display.

5:**Cycle Start** invokes a cycle start to the control when a G Code part program has been loaded into the BMDC, the program is reset, and auto run mode has been selected.

6:**Reset Alarm** causes an alarm reset command when an alarm has been discovered and cleared. Example, when the Emergency Stop switch has been reset, the alarm can be reset.

8:**Set Jog** generates a dialog box that permits the selection of the various jog modes.

| | Enter Jog Params |
|---|---|
| Axis: | <X>, <Y>, <Z>, <C>, <S> |
| Mode:F | <slow>, <Fast>, <Joy>, <Dual> |

The axis that can be selected for jog is X, Y, Z, C for rotary axis, and S for spindle axis.
The Jog modes that can be selected are:

**Slow:** Each press of the jog button moves an incremental amount of 0.0001 Inch or 0.001 Millimeter. The handwheel motion is fine. The actual movement per revolution is determined by the encoder resolution in parameter #37.

**Fast** causes the axis to move fast and for the duration that the jog button is held in. The actual jog rate is controlled by parameter #94. The handwheel motion is course.

**Joy** permits three axis joy sticks to be used as in the CMM control.

**Dual** permits two axis handwheel encoders to be active, as in the lathe control.

### 7.3 Parameter List

The following list of parameters is used by the V2XT/EXPLORER machines that are powered by the DX 32 control systems. The term CUM is Centra Micrometers or a meter raised to 10 -9BMDC parameter file — V2XT (inch screws, 250 line encoders)
Copyright (c) 1992-1993 Bridgeport Machines, Inc.

000000002.1 ; 000 ; Parameter File Revision Level (11-Aug-1993)

00000000676 ; 001 ; Low speed acceleration reg (CUMs/4Msec)
00000000676 ; 002 ; High speed acceleration reg (CUMs/4Msec)
00000003836 ; 003 ; Acceleration break point reg
00000000865 ; 004 ; Low speed deceleration reg (CUMs/4Msec)
00000001298 ; 005 ; High speed deceleration reg (CUMs/4Msec)
00000003836 ; 006 ; Deceleration break point reg
00000042333 ; 007 ; Maximum rapid traverse rate (CUMs/4Msec) (250 ipm)
00000033867 ; 008 ; Z axis Maximum rapid traverse rate (CUMs/4Msec) (200)
00000006760 ; 009 ; Feedrate for homing (CUMs/4Msec)
00000000020 ; 010 ; Feedrate Scale factor for DLT ramp down
00000001690 ; 011 ; Min-Max Feedrate for DLT ramp down (CUMs/4Msec)
00000001690 ; 012 ; Minimum reduction of following error per Tick
00000000077 ; 013 ; % of Jog following error used as FDRT per Tick
00000005080 ; 014 ; measuring feed (30.0 ipm) (CUMs/4Msec)
00000127000 ; 015 ; probing post-hit continuation distance CUMs
00000127000 ; 016 ; Touch-Probe back-off distance

These are the registers that hold the axis travel limits.

These limit registers are in CUMs !!!

```
00000000000    ; 017 ; X axis move - limit of travel register
00076200000    ; 018 ; X axis move + limit of travel register (30.0")
00000000000    ; 019 ; Y axis move - limit of travel register
00030480000    ; 020 ; Y axis move + limit of travel register (12.0")
-0012700000    ; 021 ; Z axis move - limit of travel register
00000000000    ; 022 ; Z axis move + limit of travel register (5.0")
-2147483648    ; 023 ; W axis move - limit of travel register
02147483647    ; 024 ; W axis move + limit of travel register
-2147483648    ; 025 ; S axis move - limit of travel register
02147483647    ; 026 ; S axis move + limit of travel register
```

These registers define how far from machine origin (0,0,0) the home switches are. Actually, it is the distance from the marker pulse just beyond the home switch.

```
00000508000    ; 027 ; Home switch offset in Machine resolution
00000508000    ; 028 ; Home switch offset in Machine resolution
00000508000    ; 029 ; Home switch offset in Machine resolution
00000010000    ; 030 ; Home switch offset in Machine resolution
00000010000    ; 031 ; Home switch offset in Machine resolution
```

These registers specify the encoder to CUM conversion factor for each axis.
Typically for an inch system (0.0001 inch resolution) the conversion factor will be 254 (base 10). For a metric system with a resolution of 0.001 mm, the factor is 100 (base 10).

```
00000000254    ; 032 ; X axis encoder resolution in CUMs
00000000254    ; 033 ; Y axis encoder resolution in CUMs
00000000254    ; 034 ; Z axis encoder resolution in CUMs
00000000500    ; 035 ; W axis encoder resolution in CUMs
00000000180    ; 036 ; S axis encoder resolution in CUMs
00000000500    ; 037 ; Jog Knob encoder Resolution in CUMs
```

These blocks of registers are used by the Homing routine to determine which order the axis are homed, which axis are to be homed, and the register values to be used by the homing routine.

Each block of registers contain three elements:

```
ds.l  1 ; Home switch bit number
ds.l  1 ; Home direction/enable, 0 = no home, +1 = normal, -1 = reverse
ds.l  1 ; Index of axis to be homed: 0=X, 1=Y, 2=Z, 3=W
```

```
00000000002    ; 038 ; 1st axis home switch bit number
-0000000001    ; 039 ; 1st axis home direction
```

00000000002 ; 040 ; 1st axis "axis to home"
00000000001 ; 041 ; 2nd axis home switch bit number
-0000000001 ; 042 ; 2nd axis home direction
00000000001 ; 043 ; 2nd axis "axis to home"
00000000000 ; 044 ; 3rd axis home switch bit number
-0000000001 ; 045 ; 3rd axis home direction
00000000000 ; 046 ; 3rd axis "axis to home"
00000000003 ; 047 ; 4th axis home switch bit number
00000000001 ; 048 ; 4th axis home direction
00000000003 ; 049 ; 4th axis "axis to home"

This register specifies (in CUMs) the distance within which the interpolator decides that the machine is in position.

00000007620 ; 050 ; In-Position Tolerance in CUMs

These registers store the following DAC cmd limits that are used to modify the feedrate. The DAC limits are in DAC counts. Slip is in percentage X 16.

00000002048 ; 051 ; Maximum allowable following error
00000001843 ; 052 ; FE Limit above which feedrate is reduced
00000000240 ; 053 ; Maximum allowable slip in %
00000000080 ; 054 ; Spndl slip in % above this feedrate is reduced

These registers store the measured backlash value (in CUMs).

00000002032 ; 055 ; X Axis Backlash reg
00000003048 ; 056 ; Y Axis Backlash reg
00000000000 ; 057 ; Z Axis Backlash reg
00000000000 ; 058 ; W Axis Backlash reg
00000000000 ; 059 ; S Axis Backlash reg

This register contains the value used to scale the velocity commands that are outputed from the interpolator to the Servo routines. These registers are in 28.4 format. These values allow the velocity gains of the commands to be varied relative to the position error terms.

00000000015 ; 060 ; X axis Scale factor for velocity commands
00000000015 ; 061 ; Y axis Scale factor for velocity commands
00000000015 ; 062 ; Z axis Scale factor for velocity commands
00000000015 ; 063 ; W axis Scale factor for velocity commands
00000000015 ; 064 ; S axis Scale factor for velocity commands

This register contains the value used to scale (divide) the velocity commands that are outputed to the DACs to drive the servo amplifiers. Typically, they are approximately

the same as the axes encoder resolution values because the goal is to have 1 encoder bit be reflected in a 1 bit change in the output DACs. This is a desirable feature because it provides the maximum system accuracy with the minimum stress to the axes motors and drive systems. Therefore, values of 100 to 500 are common.

00000000400 ; 065 ; X axis Scale factor for DAC velocity commands
00000000400 ; 066 ; Y axis Scale factor for DAC velocity commands
00000000400 ; 067 ; Z axis Scale factor for DAC velocity commands
00000001000 ; 068 ; W axis Scale factor for DAC velocity commands
00000000016 ; 069 ; S axis Scale factor for DAC velocity commands
These registers are used to sum up the S axis (spindle) encoder counts over a period of time to determine the spindle's actual speed. The encoder counts need to be summed up over a period of time to maintain enough resolution.

If 500 line encoder is used, the sample period is 120 (250 usec) periods
If 1024 line encoder is used, the sample period is 58 (250 usec) periods

REMEMBER Update the initialization of the SvelSamplePeriod register (param 073) if the resolution register (param 036) is changed.

NOTE The Spindle Scale factor (param 074) multiplies the desired spindle speed in RPM to obtain the required DAC command. This scale factor multiplication is followed by a shift right of 12.

SpndlScaleFactr = (MaxDacCnt/2)x(MaxDesiredVoltage/10)x(MaxRPM/4096)

00000000120 ; 070 ; Nmbr of 250 usec periods to sum Spndl velocities
00000020132 ; 071 ; Scale factor for Spindle speed commands, 20.12

In order to handle multiple gear-ranges the limits and ratios of the spindle hardware must be known and respected. If a range parameter is zero that range is not available - if range #1 is zero the spindle is manual. These parameters are used in conjunction with the "spindle type" and "spindle feedback" fields in the Master Parameter.

00000000057 ; 072 ; Spindle-Motor Minimum RPM
00000000460 ; 073 ; Spindle-Motor Maximum RPM
00000000450 ; 074 ; Spindle-Range #1 Maximum RPM
00000004200 ; 075 ; Spindle-Range #2 Maximum RPM
00000000000 ; 076 ; Spindle-Range #3 Maximum RPM
00000000000 ; 077 ; Spindle-Range #4 Maximum RPM
00000000000 ; 078 ; Spindle-Range #5 Maximum RPM
00000000000 ; 079 ; Spindle-Range #6 Maximum RPM
00000000000 ; 080 ; Spindle-Range #7 Maximum RPM
00000000000 ; 081 ; Spindle-Range #8 Maximum RPM
00000000000 ; 082 ; Spindle Analog-Feedback Scale Factor

Machine Reference Point

00000000000 ; 083 ; X-Axis Reference Point
00000000000 ; 084 ; Y-Axis Reference Point

Machine Clearance Point

00025970964 ; 085 ; X-Axis Clearance Point
00018166325 ; 086 ; Y-Axis Clearance Point
Center-Of-Rotation for Rotary Axis

00000000000 ; 087 ; X axis center of rotation
00000000000 ; 088 ; Y axis center of rotation
00000000000 ; 089 ; Z axis center of rotation

These registers define the metrics of the two tool-changers. A value of zero for maxTool indicates that that tool-changer mechanism is inactive (or not installed). The maxTool and options parameters are loaded into nvRAM in the TLAUF board as nibbles 4 and 5 (maxTool) and 6 (options). The load into the TLAUF is NOT automatically performed when the parameters are changed — a call to load TlAuf must be performed to update nvRAM.

The OPTIONS parameter is defined as follows:
Bit 3 = Input Polarity (0 = High active, 1 = Low active)
Bit 2 = not used
Bit 1-0 = Changer Type:
00 = Lightning (arm - air solenoid)
01 = 308 (arm - electric motor)
10 = spare
11 = spare

00000000000 ; 090 ; Tool-Changer #1 number of tools.
00000000000 ; 091 ; Tool-Changer #1 option flags.
00000000000 ; 092 ; Tool-Changer #1 orient position (milidegrees).
00000000000 ; 093 ; Tool-Changer #1 Z-Axis offset (CUM's).
00000000000 ; 094 ; Tool-Changer #2 number of tools.
00000000000 ; 095 ; Tool-Changer #2 option flags.
00000000000 ; 096 ; Tool-Changer #2 orient position (mili-degrees).
00000000000 ; 097 ; Tool-Changer #2 Z-Axis offset (CUM's).

The "MASTER PARAMETER" consists of 8 4-bit fields that are used by the BMDC software to index into subroutines for handling radically different implementations for the same function, such as electronic Vs air-motor spindle-speed control. The eight fields are:

Family:
- 00 - EZ-TRAK
- 01 - EXPLORER
- 02 - DISCOVERY
- 03 - FIXTURE
- 04-15 reserved

Spindle Type:
- 00 - NONE (EZ-TRAK)
- 01 - ELECTRONIC
- 02 - AIR MOTOR
- 03-15 reserved

Spindle Feedback:
- 00 - NONE (EZTRAK)
- 01 - DIGITAL ENCODER ON MOTOR
- 02 - DIGITAL ENCODER ON SPINDLE
- 03 - ANALOG from ADC #1
- 04 - ANALOG from ADC #2
- 05-15 reserved

Species:
- 00 - 15 define "species" within a family.

Fields 5 through 8 reserved

00305201152 ; 098 ; the "Master" configuration

The PositionAtHome registers define the positions to set the axes to (via SetPoint) after a FindHome operation. They are in CUMs and (usually) are the same as the most positive NORMAL travel limit (the limit registers are usually a few CUMs larger to allow for "jump" at power-up).

00076200000 ; 099 ; xPositionAtHome (25.0")
00030480000 ; 100 ; yPositionAtHome (12.0")
00000000000 ; 101 ; zPositionAtHome
00000000000 ; 102 ; wPositionAtHome
00000000000 ; 103 ; sPositionAtHome
00000000000 ; 104 ; height above tool-change (tool-holder height)
00000000555 ; 105 ; X-Axis Leadscrew Compensation
-0000001110 ; 106 ; Y-Axis Leadscrew Compensation
00000000000 ; 107 ; Z-Axis Leadscrew Compensation
00000000000 ; 108 ; W-Axis Leadscrew Compensation

These registers store the parameters used by the Spindle Power Limiter. Because more power may be available than is safe for the machine, code is included to reduce feedrate when safe power levels are exceeded.

00000000000 ; 109 ; Spindle Horsepower Limit (24.8 fmt)
00000000000 ; 110 ; RPM above which power limiter is active
00000000000 ; 111 ; Scale factor for current sensor input (24.8 fmt)

These parameters set the "Axis Run-Away" check's threshold. The run-away test measures the difference between desired velocity and actual velocity. Two metrics are adjustable; the percentage difference that is allowed and the time period (in 10 ms increments) that the difference must exceed the allowed difference before an alarm is posted.

00000001000 ; 112 ; Allowable Velocity Difference, in percent units.
00000000100 ; 113 ; Time that velocties may differ, in 10 ms units.

The following parameters are "unused" at this time...

00000000000 ; 114
00000000000 ; 115
00000000000 ; 116
00000000000 ; 117
00000000000 ; 118
00000000000 ; 119
00000000000 ; 120
00000000000 ; 121
00000000000 ; 122
00000000000 ; 123
00000000000 ; 124
00000000000 ; 125
00000000000 ; 126
00000000000 ; 127
00000000000 ; 128
00000000000 ; 129
00000000000 ; 130
00000000000 ; 131
00000000000 ; 132
00000000000 ; 133
00000000000 ; 134
00000000000 ; 135
00000000000 ; 136
00000000000 ; 137
00000000000 ; 138
00000000000 ; 139
00000000000 ; 140
00000000000 ; 141
00000000000 ; 142
00000000000 ; 143
00000000000 ; 144

```
00000000000   ; 145
00000000000   ; 146
00000000000   ; 147
00000000000   ; 148
00000000000   ; 149
```

The following "parameters" are actually the contents of LOGICAL, the machine state (switches and commands) as mapped onto a "logical" (machine- independent) bitmap. Access to them is provided to facilitate writing diagnostic aids, such as a switch-state monitor.

```
00000000000   ; 150 ; Machine Faults Byte
00000000000   ; 151 ; Axis Limits Byte
00000000000   ; 152 ; Auxiliary Limits Byte
00000000000   ; 153 ; Drive Faults Byte
00000000000   ; 154 ; Machine Status Byte
00000000000   ; 155 ; Home Switch Status Byte
00000000000   ; 156 ; Machine Options Status Byte
00000000000   ; 157 ; User Status Byte
00000000000   ; 158 ; Switch Status Byte #1
00000000000   ; 159 ; Switch Status Byte #2
00000000000   ; 160 ; Machine Command Byte #2
00000000000   ; 161 ; Machine Options Command Byte
00000000000   ; 162 ; User Command Bits Register
00000000000   ; 163 ; Spindle Command Byte
00000000000   ; 164 ; Spindle Status Byte
00000000000   ; 165 ; Commanded spindle speed (RPM)
00000000000   ; 166 ; Tool Changer #1 command register
00000000000   ; 167 ; Tool Changer Status
00000000000   ; 168 ; Tool Changer Control Register
00000000000   ; 169 ; Desired Current Tool position
00000000000   ; 170 ; Current Tool Carousel position
00000000000   ; 171 ; Inputs to TLAUF
00000000000   ; 172 ; TL1AUF output command register (for test use)
00000000000   ; 173 ; Desired NOVRAM address
00000000000   ; 174 ; Data to be written into NOVRAM
00000000000   ; 175 ; NOVRAM address
00000000000   ; 176 ; Register used by AUFDRVR to access NOVRAM
00000000000   ; 177 ; NOVRAM byte 00
00000000000   ; 178 ; NOVRAM byte 01
00000000000   ; 179 ; NOVRAM byte 02
00000000000   ; 180 ; NOVRAM byte 03
00000000000   ; 181 ; NOVRAM byte 04
00000000000   ; 182 ; NOVRAM byte 05
00000000000   ; 183 ; NOVRAM byte 06
00000000000   ; 184 ; NOVRAM byte 07
```

BRIDGEPORT MACHINES, INC.
500 Lindley Street
Bridgeport, CT 06606

# SERIES I V2XT DX-32
# Maintenance Manual

## Addendum 2/12/96
## code no. 1104-2715
## (Chapters 7 & 8)

The following is an Addendum (Code No. 1104-2715) for the Series I V2XT Maintenance Manual (Code No. 1104-1862). The chapters enclosed were not included in the first edition of the manual. Please insert these pages into your Maintenance Manual:

Chapter 7, Troubleshooting; pages 7-1 through 7-50
Chapter 8, Tests; page 8-1.

Please note that the content of Chapter 8 has been incorporated into Chapter 7.

This addendum will become obsolete when the next revision (Rev. A) of the manual is released.

# CHAPTER 7. Troubleshooting

## 7.1 INTRODUCTION

Troubleshooting consists of locating faults by starting with obvious things and moving to the less obvious. Field diagnosis of machine problems can be divided into 2 sets of checks which are listed below. A flow chart, Figure 7-1, is provided to assist in following the steps. The flow chart indicates which subsystem is likely to be at fault, and directs the technician to the proper section in this chapter. Refer to Table 7-1 for Axis Preventive Maintenance Procedures.

### 7.1.1 Procedure

Follow the chart, Figure 7-1, to determine the best place to begin troubleshooting the system. The two major sets of checks are:

1. Incoming Power (Section 7.2.1)
2. Power Supplies (Section 7.2.2)

Additional checks for spindle problems are presented in the Axis Troubleshooting Chart (Table 7-2). Additional information is in Chapter 6 - Axis Drive System.

Use the system wiring diagram to follow the electrical checks and to perform any additional electrical checks if necessary.

## 7.2 ELECTRICAL POWER TEST

Lethal voltages are present in the electrical cabinet, even when the Main Disconnect switch is off. Use extreme caution whenever working in the electrical cabinet. Failure to do so may cause electric shock, resulting in serious personal injury or death.

Power enters the machine at the Main Disconnect switch on the electrical cabinet. Then it is distributed inside the electrical cabinet.

### 7.2.1 Incoming Power

1. The proper ac power voltage is indicated on the label outside of the electrical cabinet. Insure that the correct voltage is supplied to the machine. If not, refer to the System Wiring Diagram for the proper jumper configuration.
2. The incoming power goes directly from the circuit breaker to transformer T1 and T2. Check to insure that 1L1, 1L2, and 1L3 are connected to the terminals that equal the incoming power value, i.e., 230 vac incoming requires that 1L1 and 1L2 be connected to terminals H1 and H3; that terminals H1, H3 be connected to terminals H4, H6 for T1; that 1L3, 1L2 be connected to terminals H1, H7; and that terminals H1, H3 be connected to terminals H5, H7 for T2.

If these wires must be changed, do not move any other wires. They have already been checked for proper installation.

3. Turn on the control and measure the voltage on the input 1L1, 1L2, and 1L3, to transformers T1 and T2.
4. Measure the output voltage from transformers T1 and T2:

T1:

| **Wire No.** | **Machine** |
|---|---|
| X8, X7 | 110 vac |

T2:

| **Wire No.** | **Machine** |
|---|---|
| 2 - 3 | 68-75 vac |
| 2 - 4 | 110-130 vac |

If the output voltage is not correct, repair the connection(s) or replace T1, T2 or as necessary.

# CHAPTER 7. Troubleshooting

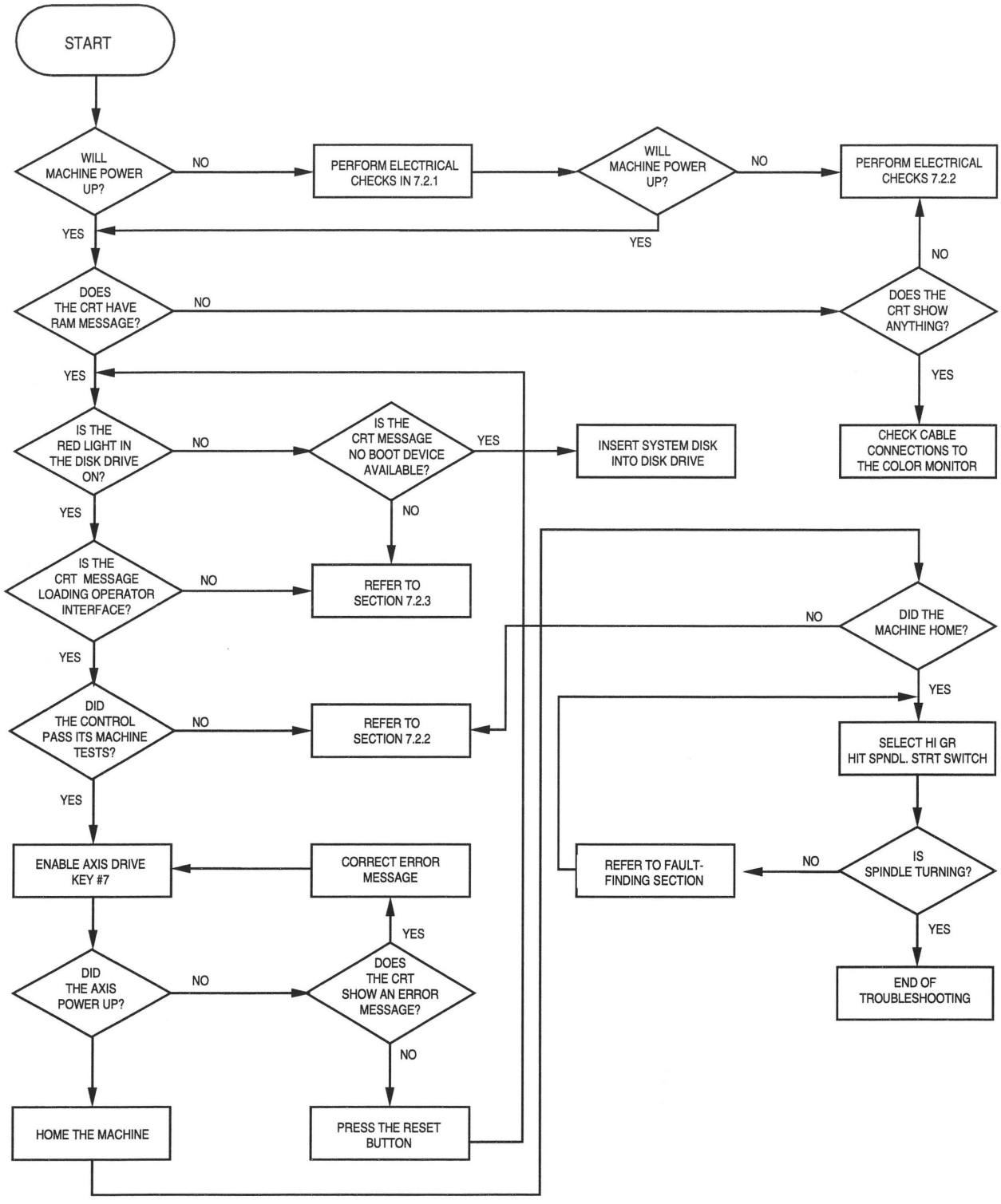



**Figure 7-1.** Troubleshooting Flowchart

# CHAPTER 7. Troubleshooting

**Table 7-1. Axis Preventive Maintenance Procedures**

| Item | Procedure | Time |
|---|---|---|
| Positioning Accuracy | As a normal manufacturing procedure, check the parts made. Check the electrical positioning accuracy and the mechanical machine accuracy. | As Required |
| Voltage Checks | Check voltages listed under 7.2.1, paragraphs 1 through 4 and 7.2.2 paragraph 1. | Semiannual |

**Table 7-2. Axis Troubleshooting Chart**

| Symptom | Possible Cause |
|---|---|
| Power Transistor Failure | The fault sensor is defective.<br>Switching logic is defective on the printed circuit board. |
| Contouring Inaccuracy | Gains of all axes are not identical.<br>There is servo current limiting in contouring speed range. |
| Inadequate Performance | The required accelerating current is not available.<br>There is excessive lost motion such as backlash or windup.<br>There is low frequency mechanical resonance (check by observing open loop response). |
| Position Overshoot | The current limit is too low, or the tachometer gain is too low. |
| Poor Surface Finish | The position loop gain is too high.<br>The tachometer is noisy.<br>There is a defective feedback device or device excitation.<br>A machine drive member is defective.<br>Machine tooling is defective. |
| No Motion (All Axes) | The customer's protective interlocks are set.<br>The main supply fuse is open. |
| Overcurrent Fault (1 Per Axis) | There is an armature circuit fault.<br>The current limit is inoperative or set too high.<br>The armature is shorted to ground. |
| Instability During Power Enable | The position or velocity transducer signal is reversed or the armature wires are reversed.<br>The velocity command is not correct.<br>The position or velocity transducer signal is lost.<br>A printed-circuit board is defective. |
| Instability | The axis is not tuned properly.<br>The position loop gain is too high.<br>The high frequency gain is improperly set.<br>Multiply position loop gains are improperly adjusted (if they are used in the controller). |

Table 7-2. Axis Troubleshooting Chart (Continued)

| Symptom | Possible Cause |
|---|---|
| Instability Manifested by Low Amplitude and/or Low Frequency Oscillation | There is high static to running friction action.<br>Backlash or deadband is present in the machine or transducer. |
| Positioning Accuracy | High friction is present.<br>Position loop gain and/or low frequency gain of velocity loop is low.<br>There is backlash or wind-up in the position transducer/motion connection.<br>The tool reaction forces are too high to be consistent with high accuracy.<br>Pulley is loose on motor shaft.<br>Encoder output not accurate. |
| Positioning Cycle Time Too Long | The final position is overshot.<br>The speed is low.<br>Current limit is set too low. |
| Excessive Machine Wear | Current Limit is set too high or is inoperative.<br>The ripple current in the motor is too high due to noise injected from the transducers. |
| Motor Overheats | The friction level is too high.<br>Current limit is set too high or is inoperative.<br>There is a noise from the transducers that is being injected into the servo.<br>The duty cycle is too severe.<br>The inertia is high.<br>There are high tool reaction forces requiring high motor current.<br>Permanent magnet fields have been demagnetized, causing high armature current to develop torque. |
| Poor Speed Regulation Top Speed | Friction is too high<br>The motor is incapable of operating at the speed being commanded. |
| Axis-to-Axis Speed Interaction | Power supply capacitance is too small, allowing voltage to dip during motor acceleration.<br>Incoming ac line voltage is dipping during acceleration of the motor and allowing the +600 volt bus to drop.<br>High friction of inertia load is pulling the +600 volt bus low.<br>Poor ground connection.<br>The rectifiers are bad or there is some other problem causing the rectification in the power supply to be half wave rather than full wave, creating a low voltage +600 volt bus under load. |
| Erratic Motor Operation | Noise is manifested in the motor current introduced into the servo by transducers.<br>There is poor grounding or there are loose connections.<br>There is a jump on startup or shutdown due to improper interfacing. |

### 7.2.2 Power Supplies

1. This system has a 24 vdc power supply to check. Measure the following voltages:

| Wire No. | Voltage | Location |
|---|---|---|
| 7 to 8 | 19 vac +/- 2V | FU10 |
| 40 to 39 | 24 vdc +/- 2V | FU9 |

2. Check Wires 50 to 2 for 105 vdc, +/-5 vdc, for the motor drives.

3. To check the voltages to the AUF card, make make the following readings:

| Terminals | Voltage |
|---|---|
| JP22-3A to JP22-1A | 115 vac +/- 7.5 vac |
| JP12-1A to JP12-2A | 24 vdc +/- 2 vdc |

The power to the BMDC comes from the 486 SX card. The AUXBOB, and the AXSBOB cards receive their power through the 50 pin cable that connects them to the BMDC.

### 7.2.3 DX 32 Power System

1. The DX power supply supplies positive 12 volts, 5 volts and negative 12 volts to the 486 board through connectors P8 and P9. They plug into connectors PS1 and PS2 on the 386/486 board.

**CAUTION**

If it is necessary to install P8 and P9 for any reason, INSURE that the black wires on each connector are next to each other, and that the red wires are on the end toward the bottom of the cabinet on PS1 & PS2 pins 10, 11, and 12.

2. To read the voltage from the power supply, measure all voltages with respect to the black wires, ground.

| Connector | Reading |
|---|---|
| PS1, PS2 Pins 5, 6, 7, or 8 to Pin 10, 11, 12 | +5 Volts |
| PS1, PS2 Pins 5, 6, 7, or 8 to Pin 9 | -5 Volts |
| PS1, PS2 Pins 5, 6, 7, or 8 to Pin 4 | -12 Volts |
| PS1, PS2 Pins 5, 6, 7, or 8 to Pin 3 | +12 Volts |

3. The DX power supply also supplies power to the floppy disk drive. Locate J2 and read the following voltages:

| Connector (Wire) | Reading |
|---|---|
| Red to Black | +5 vdc |
| Yellow to Black | +12 vdc |

4. If there is no voltage from the DX power supply, check the 115 vac on the input at wires 10 and 11. This supply also has an internal 5 amp fuse on the card. Check to insure that the fuse is in good working order.

**NOTE**

The power supply will not work without a load on the +vdc pins.

5. The color monitor (CRT) in the front panel is self-contained; the only supply voltage is 115 vac on the power cord at the backing of the unit. If this voltage is present and the CRT is still black, check to insure that the power OFF-ON switch is in the ON position. Also, this unit contains a 3 amp fuse on the 115 vac line. Check to insure that the fuse is in good working order.

6. Troubleshooting suggestions:

| Problem | Checks to make |
|---|---|
| Color monitor is dead | 1. Check voltages<br>2. Check power-on switch.<br>3. Check fuses.<br>4. Check power cord.<br>5. Insure brightness thumb wheel is turned up. |

| | |
|---|---|
| Color monitor has Raster but no video | 1. Check the 386/486 Card for power<br>2. Check that video cable is plugged into monitor and into the 386/486 card (J21). |
| Color monitor is dark | 1. Adjust the brightness control |
| Color monitor will not synchronize | 1. Adjust the horizontal or vertical hold control |
| Color monitor display message<br>NO BOOT DEVICE AVAILABLE.<br>OPERATING SYSTEM MISSING | 1. Check voltage on the floppy disk drive.<br>2. No system disk in the drive unit (if booting from floppy).<br>3. Check C drive<br>4. Check the signal cable from the 386/486 board. |

**DIAGNOSTICS AND PARAMETER FILES**
The V2XT/EXPLORER control is equipped with a set of real-time diagnostics that run in the background. When a diagnostic test discovers a violation of operation limits, it stops the control and posts a message to the operator. The parameter files are used to set the limits for these tests and to describe to the software the function of the machine in which the software is installed.

**PFM PROGRAM -** The Parameter File Maintenance (PFM) program is designed to enable the editing of the parameter file in a more intelligent manner. The actual numbers in the parameter file appear in different machine units for most parameters and must be translated to more recognizable units. The PFM program consists of two separate programs. They are the Parameter Editor and the Tuner program.

**CAUTION**

The file that the Parameter Editor changes is unique to the machine in which it is installed. This file is BMDCPRMS.SYS. To maintain a copy of the original numbers, either copy the file to a floppy disc or make a copy on the hard disk renamed to something like *.OLD.

To get to use the PFM program, page the control back to the Basic Menu window. Select button 9 (DOS). The message window will display "Exit to DOS? <Y> to exit". Type Y. A DOS prompt will appear (C:\>). Type PFM <enter>. The control will load the PFM program into the 386/486 PC board. A dialog box will appears as shown below.

```
Please Select One
Exit Program
Parameter Editor
Tuner
```

While in PFM, each editor program will present a window that will enable the user to accomplish a different task. Within that window will be a dialog box that has specific instructions on how to use that window. The title of this box is "What To Do Now." In this case, the box will have the following instructions. Use UP and DOWN arrow keys to select, the ENTER key to choose, or the ESC key to exit. Arrow down to Parameter Editor and Enter.

**NOTE**

The Escape (ESC) key will allow the exit from most windows.

**PARAMETER EDITOR -**The parameter editor is used to install or modify numbers in the parameter file. This file is established and installed at the time that the machine is built. Modification of any parameter in this file in the field should be done only after consulting the factory.

On entering this editor, a series of dialog boxes will be displayed to the user. A recreation of these boxes appears below.

| Parameter File Window: Center Line Is Current Parameter |
|---|
| 00000000 ; Previous Parameter |
| 00000001 ; Current Parameter |
| 00000002 ; Next Parameter |

| Information About Currently Selected Parameter |
|---|
| Three lines of help specific to the parameter that is being edited will appear here. |

| New Value |
|---|
| What You Type In |

| What To Do Now |
|---|
| Two Line of General Information about what to do now: edit field , choose from list, etc. |

| General Instructions |
|---|
| Hit any Key to Begin Editing Parameters. |

When a key is hit, a new dialog box appears as shown:

| Please Select One |
|---|
| Exit Param Editor |
| Edit Param File |
| Edit Machine Params |

The Exit Param Editor returns the user to the first page. The Edit Param File will change the stored file and the present operating file but restricts the use of the "read only" parameters. Edit Machine Params will change the operating parameters in the machine immediately and permit the examination of parameters above 149 in real time. These parameters include switch closures and machine commands (refer to the parameter listing at the end of this chapter).

Select Edit Machine Params file and Enter. The parameter file window now displays new numbers and the parameter numbers can now be modified. The window will be displayed as shown below.

| Parameter File Window: Center Line is Current Selection |
|---|
| 00000001693 ; #1 Low Speed (below breakpoint) Acceleration |
| 00000001693 ; #2 High Speed (above breakpoint) Acceleration |
| 00000050969 ; #3 Acceleration breakpoint |

Note that the 11 digit number now represents a parameter in machine units, and without a working knowledge of the machine software and its use in the software, the number is unintelligible. Also, the current parameter will be highlighted. To go to the edit mode, select a parameter and press Enter. In the case of parameter #2, the New Value and the Information About the Current Parameter, and the What To Do Next box change:

| New Value |
|---|
| 9.998031 |

The What To Do Next box is

| What To Do Next |
|---|
| Enter New Value in INCHES PER MINUTE |

The Information About Current Parameter box displays a brief description about the parameter. (Refer to the parameter file listing at the end of the paragraph for the text that will be displaced for parameter #2.)

The New Value box can now be modified. When Enter is pressed, the new value becomes active.

After the new values and the parameters are determined to be acceptable, the parameters can be saved by pressing ESC. A new dialog box will appear as shown below.

| Please Select One |
|---|
| NO-Discard Changes |
| YES-Update File |

About the two selections: "NO-Discard Changes" discards any changes made; "YES-Update File" writes the changes to the stored parameter file where they will be used until they are again updated.

**READ ONLY PARAMETERS -** The V2XT/EXPLORER machine is equipped with a set of parameters that can be useful for checking switch closures and commands to start functions assigned to the machine. These parameters start at parameter #150 and go up to parameter #172. To view these parameters, enter Edit Machine Params. Page up to the desired parameter or press G followed by the parameter number and press Enter. The Information About Currently Selected Parameter window will display a listing of the number that appears in the New Value window. Below is an example of these windows for parameter #164.

| Information About Currently Selected Parameter<br>Spindle Status Word<br>PN,HG,LG,SB,AS,ZS,SR where : PN=Pin, HG= HiGr, LG=LoGr SB=Spindle Brake, SH=Spindle Home, AS=At Speed, ZS=Zero Speed, SR=Spindle Ready. |
|---|

The New Value dialog box will be as shown.

| New Value<br>00000000 |
|---|

The digits in this box are real-time and are updated when a change in their status occurs. The digits correspond to the function as described in the Information About Currently Selected Parameter window.

The What To Do Window will be as shown.

| What To Do Now |
|---|
| Live (non-Editable) |
| Read-Only Parameter |

**LEADSCREW COMPENSATION -** The V2XT/EXPLORER machine has one set of parameters for compensating the inaccuracy of the leadscrew on each axis. The leadscrew compensation is a linear adjustment that is prorated across the length of travel. The inaccuracy of the leadscrew is established by reading from the 0 position to the end of maximum travel of the axis to determine the actual distance traveled The formula for calculating the input number is Leadcomp = (ideal resolution X Ideal distance divided by Real distance) - Ideal resolution) X 65536.

Example:
Assume ideal res is 50 cums (para 32 thru 36)
Assume ideal dist is 20 inches
Assume measured dist is 19.999 inches
Leadcomp = ((50 X 20" /19.999") - 50) X 65536
Leadcomp = 163.848
Round out this value to 164 and install in the correct parameter 105 thru 108.

**The TUNER PROGRAM -** This program was designed to aid in setting up the machine at factory start up. This program can be useful in testing the performance of the control in the field.

To load the TUNER program, enter the PFM program as described at the beginning of this paragraph. When the following dialog box appears, page down to highlight the TUNER selection and press Enter.The TUNER program will be loaded into the 486 PC where it will supervise the performance of the BMDC in real-time.

| Please Select One |
|---|
| Exit Program |
| Parameter Editor |
| Tuner |

The Tuner is pictured on the top of the next page.

| | POS | POS-ERR | DAC-CMD | DAC-OFF | HOME-SW | Feed Cmd: 0.0000 |
|---|---|---|---|---|---|---|
| X-axis | 0.0001 | 0.0000 | 00000 | 00000 | OFF | Feed Ovr: 200% |
| Y-axis | 0.0000 | 0.0000 | 00000 | 00000 | ON | Feed Act: 0.0000 |
| Z-axis | 0.0002 | 0.0000 | 00000 | 00000 | OFF | |
| C-axis | 0.0000 | 0.0000 | 00000 | 00000 | | RPM Cmd: 0.0000 |
| S-axis | 0.0000 | 0.0000 | | 00000 | 00000 | RPM Ovr: 100% |
| | | | | | | RPM Act: 0.0000 |
| Prev: | | | | | TL: 0.00 | Load: 001% |
| Cur: | | | | | TD: 0.00 | |
| Next: | | | | | 000:00:00 | MOVE: *DONE* |

| | | | |
|---|---|---|---|
| F1:Event Log | F2:Backlash | F3:LeadComp | F4:Position:DES |
| F5:ABS / INC: ABS | F6:Inch / MM: IN | F7:Drives:OFF | F8:Home X,Y |
| F9:Enter Move | F10:Enter Offsets | 1:MDI | 2:Load program |
| 3:Reset Program | 4:Mode: Setup | 5:Cycle Start | 6:Reset Alm Alarm |
| | | 8: Set Jog | |

```
BMDC version 6.20 running
reading param file....
File Version is 3.20
setting 149 params....
done setting parameters.
Loading leadcomp file....
Done loading Multi-Point Compensation Tables
```

The continued dialog is an explanation of that display.

The first column to the top left of the display describes the axis to which the information applies. The headers at the top are as follows: POS is the commanded position; POS-ERR is the difference from Actual Position and Commanded Position; DAC-CMD is the actual digital number that is presented to the digital to analog converter; DAC-OFF is the amount of DAC offset, and HOME-SW is the state of the home switches.

The **POS** column can be used to determine the command for the axis motion. This column is updated by the encoder on the motor of each axis. Before the machine is homed but with the drives in OFF, turn the motor shaft to have POS count the pulses. After the drives are on and the machine is homed, select 8 and enter an axis to jog.The manual jog will update the POS column as it is jogged. The display is 0.0001 inch resolution.

**POS-ERR** can be used to determine the difference between actual and commanded position. This column is dynamic and can be used to determine the following error during acceleration and constant velocity of an axis. This column is used for matching the following error on the X- and Y-axis during the FERROR program. Also matching the S-axis and Z-axis following error during the coordinated tapping cycle is another example. The unit for this column is 0.0001 inches.

**NOTE**

On this page the BMDC software and the Parameter file version can be found. The parameter file is modified to suit the

characteristics of the machine at time of startup. Therefore, each parameter file is different from the next machine. The characterization of this file does not change the software version found on the display. The version number applies to the software in which the parameters are contained.

**DAC-CMD** is used to balance the axis drive offset when the axis in position. The display should be adjusted to read 0.0000 with the axis balance pot. The DAC have a range of +/- 2048 which is equal to +/- 10 Volts.

**DAC-OFF** is little used in the field. It is the offset required to hold a motor at zero.

**HOME-SW** displays the status of the home switches. The first use of this display is to assure that the switches are working. The second use is to set the distance from home to the switch. To set the switch accurately, it is important to determine the amount of travel for 3/4 of a revolution on the motor. Example: on an 8 mm leadscrew geared 2:1 to the motor, 1 revolution of the motor is 4 mm. 3/4 of 1 revolution is 3 mm. To set the switch correctly, press F4, which will switch the display from inches to metric. Home the machine. If the position display is anything but 0.000, press F10. Enter 0.000 into the axis display to be checked. (Refer to F10:Entering Offsets later in this chapter) Now jog the axis off the switch and slowly back on to it with the Jog Knob. When the switch changes state to On, the readout should read 3 MM +/-.01. If the readout is not within this range, set the readout for 3 MM and adjust the switch to close at this point. Again, back off the switch and check the distance to home.

**FEED CMD** is the commanded feed rate for a given move in the G01,02, 0r 03 mode.

**FEED OVR** is the amount of feed rate override in effect for the move.

**FEED ACT** is the actual feed rate used for a commanded move. Actual feedrate is the commanded feedrate times the feed-rate override times vectorial velocity.

**RPM CMD** is the commanded spindle RPM.

**RPM OVR** is the amount of spindle RPM override being used.

**RPM ACT** is the actual spindle RPM commanded. RPM Actual is the RPM commanded times the RPM override.

**LOAD** is the percentage of 7.5 horsepower being generated by the spindle motor.

**PREV** is the previous line of information commanded by the part program.

**CUR** is the current line on information commanded by the part program.

**NEXT** is the next line of part program to be acted on by the control.

**TL** is the tool length being used by the tool number in the spindle.

**TD** is the tool diameter called from by the tool table for the tool in the spindle.

| | | | | |
|---|---|---|---|---|
| Enter LeadComp | ( "*" = no change) | | | |
| X: Expected : | 18.0000 | Measured | 18.0000 | INCHES |
| Y: Expected : | 12.0000 | Measured | 12.0000 | INCHES |
| Z: Expected : | 15.0000 | Measured | 14.0000 | INCHES |
| C: Expected : | 17179.869180 | Measured | 17179.869180 | DEGREES |

**000:00:00** is time to the second.

**MOVE: *DONE*** is the status of the control. If a move is being processed, the status is Active. In the Jog Mode the control is always active because the Jog handwheel is always capable of moving the selected axis. If a move is not complete, the done status will never come on. This state could exist if the servo gains were low or the In Position window was too small.

F1: **Event Log** is a storage space for 16 events that affect the performance of the control. An example is any error that causes emergency stop or tool change time. This log is erased when the machine is shut off.

F2: **Backlash** is a method to enter backlash compensation into the machine.
The window is:

| Enter Backlash ("*" = no change) | | |
|---|---|---|
| X: | 0.0000 | inches |
| Y | 0.0000 | inches |
| Z: | 0.0000 | inches |
| C: | 0.0000 | inches |

The number entered in here is stored in parameters #55 thru #59.

F3: **LeadComp** is a simplified method to activate the linear leadscrew compensation parameter. (Refer to the display that is pictured on the previous page.) The entries inserted into the dialog box are converted by the formula described above and entered into the appropriate parameter for that axis (#105 thru #108). The dialog box will request two entries for each axis to be compensated. They are the expected dimension which is generally the distance for total travel on that axis and the measured distance for that travel. When entering numbers into this box, use the asterisk key to pass an axis that should not be changed. Pressing an enter to skip an axis will enter a zero.

F4: **Position** changes the POS display on the top left on the CRT screen from Desired to Actual position. It will toggle each time the F4 button is pressed.

F5: **ABS / INC** will toggle the control from absolute to incremental mode. This status will affect the manual move information input into the control.

F6: **Inch / MM** will toggle the control from inches to metric with each stroke. The display will change from 4 digits to the right of the decimal for inches to 3 digits for metric.

F7: **Drives** will toggle the power to the axis motors on and off with each stroke. The control will compensate for the appropriate functions when this key is used. Example: the Z brake will turn on and off with the drives.

F8: **Home** will home all axes and the toolchanger if it is present.

F9: **Enter Move** will present a dialog box that will enable many possible moves to be entered. The dialog box is shown below.

| Enter Move | | |
|---|---|---|
| Mach, Usr Coords 0,1=Move 2,3=Jog | | |
| Taper 4-9=JogArc: 0 | | |
| X: | 0.0000 | INCHES |
| Y | 0.0000 | INCHES |
| Z | 0.0000 | INCHES |
| C: | 0.00000 | DEGREES |

The move mode is selected as follows.

0 Move in machine coordinates.
1 Move in user coordinates.
2 Jog-Taper in machine coordinates.
3 Jog-taper in user coordinates.
4 Jog-arc in machine coordinates on the X and Y plane.
5 Jog-Arc in user coordinates on the X and Y plane.

6 Jog-Arc in machine coordinated in the X and Z plane.
7 Jog-Arc in user coordinates in the X and Z plane
8 Jog-Arc in machine coordinates in the Y and Z plane
9 Jog-Arc in user coordinates in the Y and Z plane.

F10: **Enter Offsets** will present a dialog box as shown below.

```
Enter Offsets ( "*" = no change )
    Coord System (0=Base 1=user) : 0
    X:          0.0000          INCHES
    Y:          0.0000          INCHES
    Z           0.0000          INCHES
    C:          0.0000          INCHES
    S:          0.0000          INCHES
```

**CAUTION**

Base coordinates are installed when the machine is homed. Care must be taken when entering information into these offsets. The default is set to BASE coordinate system. If any inputs are made in the base system, the machine is permitted to operate within the software limits but the base reference has been moved. The result is that the axis can exceed the mechanical limits in a rapid rate. To recover, reset the machine and reload the control software. To use the USER coordinates, enter a 1 for the coordinate system. The user can now preset the POS display to read the number entered into the appropriate axis. Example: if an axis has 20 inches of travel and the axis is at home when the user system coordinates are changed to read -5 inches, the control will operate from the readout position of -5 inches to -25 inches. If the coordinates were changed to plus 5 inches, the machine would operate between 5 inches and -15 inches. A command of axis "0" will be -5 inches from home.

1: **MDI** permits a manual move to be entered a line at a time.

2: **Load program** generates a dialog box that permits the user to type in a title of a part program to be loaded to the BMDC for execution when the control is in auto and cycle start is requested.

3: **Reset Program** readies the control to start operation from the beginning of a stored part program on the BMDC.

4: **Mode** will change the function of the control as requested. The following dialog box will be displayed.

```
Select Mode
<S>etup,<B>lock,<A>uto,<P>c,Pre<V>iew:
```

**Setup** mode is used for most non-programmed operations.

**Block** mode is used to execute one G Code statement at a time.

**Auto** places the control in a mode that initiates an auto-run when cycle start is commanded.

**PC** is a special function that permits the PC software to issue a sequence of commands to the BMDC, as in the probing mode.

**PreView** is a mode where the part program on the BMDC is parsed a line at a time to the front end when the front end requests it for graph display.

5:**Cycle Start** invokes a cycle start to the control when a G Code part program has been loaded into the BMDC, the program is reset, and auto run mode has been selected.

6:**Reset Alarm** causes an alarm reset command when an alarm has been discovered and cleared. Example, when the Emergency Stop switch has been reset, the alarm can be reset.

8:**Set Jog** generates a dialog box that permits the selection of the various jog modes.

| Enter Jog Params | |
|---|---|
| Axis: | <X>, <Y>, <Z>, <C>, <S> |
| Mode:F | <slow>, <Fast>, <Joy>, <Dual> |

The axis that can be selected for jog is X, Y, Z, C for rotary axis, and S for spindle axis.
The Jog modes that can be selected are:

**Slow:** Each press of the jog button moves an incremental amount of 0.0001 Inch or 0.001 Millimeter. The handwheel motion is fine. The actual movement per revolution is determined by the encoder resolution in parameter #37.

**Fast** causes the axis to move fast and for the duration that the jog button is held in. The actual jog rate is controlled by parameter #94. The handwheel motion is course.

**Joy** permits three axis joy sticks to be used as in the CMM control.

**Dual** permits two axis handwheel encoders to be active, as in the lathe control.

The following list of parameters is used by the V2XT/EXPLORER machines that are powered by the DX 32 control systems. The term CUM is Centra Micrometers or a meter raised to 10 -9BMDC parameter file — V2XT (inch screws, 250 line encoders)
Copyright (c) 1992-1993 Bridgeport Machines, Inc.

000000002.1 ; 000 ; Parameter File Revision Level (11-Aug-1993)

00000000676 ; 001 ; Low speed acceleration reg (CUMs/4Msec)
00000000676 ; 002 ; High speed acceleration reg (CUMs/4Msec)
00000003836 ; 003 ; Acceleration break point reg
00000000865 ; 004 ; Low speed deceleration reg (CUMs/4Msec)
00000001298 ; 005 ; High speed deceleration reg (CUMs/4Msec)
00000003836 ; 006 ; Deceleration break point reg
00000042333 ; 007 ; Maximum rapid traverse rate (CUMs/4Msec) (250 ipm)
00000033867 ; 008 ; Z axis Maximum rapid traverse rate (CUMs/4Msec) (200)
00000006760 ; 009 ; Feedrate for homing (CUMs/4Msec)
00000000020 ; 010 ; Feedrate Scale factor for DLT ramp down
00000001690 ; 011 ; Min-Max Feedrate for DLT ramp down (CUMs/4Msec)
00000001690 ; 012 ; Minimum reduction of following error per Tick
00000000077 ; 013 ; % of Jog following error used as FDRT per Tick
00000005080 ; 014 ; measuring feed (30.0 ipm) (CUMs/4Msec)
00000127000 ; 015 ; probing post-hit continuation distance CUMs
00000127000 ; 016 ; Touch-Probe back-off distance

These are the registers that hold the axis travel limits.

These limit registers are in CUMs !!!

```
00000000000   ; 017 ; X axis move - limit of travel register
00076200000   ; 018 ; X axis move + limit of travel register (30.0")
00000000000   ; 019 ; Y axis move - limit of travel register
00030480000   ; 020 ; Y axis move + limit of travel register (12.0")
-0012700000   ; 021 ; Z axis move - limit of travel register
00000000000   ; 022 ; Z axis move + limit of travel register (5.0")
-2147483648   ; 023 ; W axis move - limit of travel register
02147483647   ; 024 ; W axis move + limit of travel register
-2147483648   ; 025 ; S axis move - limit of travel register
02147483647   ; 026 ; S axis move + limit of travel register
```

These registers define how far from machine origin (0,0,0) the home switches are. Actually, it is the distance from the marker pulse just beyond the home switch.

```
00000508000   ; 027 ; Home switch offset in Machine resolution
00000508000   ; 028 ; Home switch offset in Machine resolution
00000508000   ; 029 ; Home switch offset in Machine resolution
00000010000   ; 030 ; Home switch offset in Machine resolution
00000010000   ; 031 ; Home switch offset in Machine resolution
```

These registers specify the encoder to CUM conversion factor for each axis.
Typically for an inch system (0.0001 inch resolution) the conversion factor will be 254 (base 10). For a metric system with a resolution of 0.001 mm, the factor is 100 (base 10).

```
00000000254   ; 032 ; X axis encoder resolution in CUMs
00000000254   ; 033 ; Y axis encoder resolution in CUMs
00000000254   ; 034 ; Z axis encoder resolution in CUMs
00000000500   ; 035 ; W axis encoder resolution in CUMs
00000000180   ; 036 ; S axis encoder resolution in CUMs
00000000500   ; 037 ; Jog Knob encoder Resolution in CUMs
```

These blocks of registers are used by the Homing routine to determine which order the axis are homed, which axis are to be homed, and the register values to be used by the homing routine.

Each block of registers contain three elements:

```
ds.l  1 ; Home switch bit number
ds.l  1 ; Home direction/enable, 0 = no home, +1 = normal, -1 = reverse
ds.l  1 ; Index of axis to be homed: 0=X, 1=Y, 2=Z, 3=W
```

```
00000000002   ; 038 ; 1st axis home switch bit number
-0000000001   ; 039 ; 1st axis home direction
```

00000000002 ; 040 ; 1st axis "axis to home"
00000000001 ; 041 ; 2nd axis home switch bit number
-0000000001 ; 042 ; 2nd axis home direction
00000000001 ; 043 ; 2nd axis "axis to home"
00000000000 ; 044 ; 3rd axis home switch bit number
-0000000001 ; 045 ; 3rd axis home direction
00000000000 ; 046 ; 3rd axis "axis to home"
00000000003 ; 047 ; 4th axis home switch bit number
00000000001 ; 048 ; 4th axis home direction
00000000003 ; 049 ; 4th axis "axis to home"

This register specifies (in CUMs) the distance within which the interpolator decides that the machine is in position.

00000007620 ; 050 ; In-Position Tolerance in CUMs

These registers store the following DAC cmd limits that are used to modify the feedrate. The DAC limits are in DAC counts. Slip is in percentage X 16.

00000002048 ; 051 ; Maximum allowable following error
00000001843 ; 052 ; FE Limit above which feedrate is reduced
00000000240 ; 053 ; Maximum allowable slip in %
00000000080 ; 054 ; Spndl slip in % above this feedrate is reduced

These registers store the measured backlash value (in CUMs).

00000002032 ; 055 ; X Axis Backlash reg
00000003048 ; 056 ; Y Axis Backlash reg
00000000000 ; 057 ; Z Axis Backlash reg
00000000000 ; 058 ; W Axis Backlash reg
00000000000 ; 059 ; S Axis Backlash reg

This register contains the value used to scale the velocity commands that are outputed from the interpolator to the Servo routines. These registers are in 28.4 format. These values allow the velocity gains of the commands to be varied relative to the position error terms.

00000000015 ; 060 ; X axis Scale factor for velocity commands
00000000015 ; 061 ; Y axis Scale factor for velocity commands
00000000015 ; 062 ; Z axis Scale factor for velocity commands
00000000015 ; 063 ; W axis Scale factor for velocity commands
00000000015 ; 064 ; S axis Scale factor for velocity commands

This register contains the value used to scale (divide) the velocity commands that are outputed to the DACs to drive the servo amplifiers. Typically, they are approximately

the same as the axes encoder resolution values because the goal is to have 1 encoder bit be reflected in a 1 bit change in the output DACs. This is a desirable feature because it provides the maximum system accuracy with the minimum stress to the axes motors and drive systems. Therefore, values of 100 to 500 are common.

00000000400 ; 065 ; X axis Scale factor for DAC velocity commands
00000000400 ; 066 ; Y axis Scale factor for DAC velocity commands
00000000400 ; 067 ; Z axis Scale factor for DAC velocity commands
00000001000 ; 068 ; W axis Scale factor for DAC velocity commands
00000000016 ; 069 ; S axis Scale factor for DAC velocity commands
These registers are used to sum up the S axis (spindle) encoder counts over a period of time to determine the spindle's actual speed. The encoder counts need to be summed up over a period of time to maintain enough resolution.

If 500 line encoder is used, the sample period is 120 (250 usec) periods
If 1024 line encoder is used, the sample period is 58 (250 usec) periods

REMEMBER Update the initialization of the SvelSamplePeriod register (param 073) if the resolution register (param 036) is changed.

NOTE The Spindle Scale factor (param 074) multiplies the desired spindle speed in RPM to obtain the required DAC command. This scale factor multiplication is followed by a shift right of 12.

SpndlScaleFactr = (MaxDacCnt/2)x(MaxDesiredVoltage/10)x(MaxRPM/4096)

00000000120 ; 070 ; Nmbr of 250 usec periods to sum Spndl velocities
00000020132 ; 071 ; Scale factor for Spindle speed commands, 20.12

In order to handle multiple gear-ranges the limits and ratios of the spindle hardware must be known and respected. If a range parameter is zero that range is not available - if range #1 is zero the spindle is manual. These parameters are used in conjunction with the "spindle type" and "spindle feedback" fields in the Master Parameter.

00000000057 ; 072 ; Spindle-Motor Minimum RPM
00000000460 ; 073 ; Spindle-Motor Maximum RPM
00000000450 ; 074 ; Spindle-Range #1 Maximum RPM
00000004200 ; 075 ; Spindle-Range #2 Maximum RPM
00000000000 ; 076 ; Spindle-Range #3 Maximum RPM
00000000000 ; 077 ; Spindle-Range #4 Maximum RPM
00000000000 ; 078 ; Spindle-Range #5 Maximum RPM
00000000000 ; 079 ; Spindle-Range #6 Maximum RPM
00000000000 ; 080 ; Spindle-Range #7 Maximum RPM
00000000000 ; 081 ; Spindle-Range #8 Maximum RPM
00000000000 ; 082 ; Spindle Analog-Feedback Scale Factor

Machine Reference Point

00000000000 ; 083 ; X-Axis Reference Point
00000000000 ; 084 ; Y-Axis Reference Point

Machine Clearance Point

00025970964 ; 085 ; X-Axis Clearance Point
00018166325 ; 086 ; Y-Axis Clearance Point
Center-Of-Rotation for Rotary Axis

00000000000 ; 087 ; X axis center of rotation
00000000000 ; 088 ; Y axis center of rotation
00000000000 ; 089 ; Z axis center of rotation

These registers define the metrics of the two tool-changers. A value of zero for maxTool indicates that that tool-changer mechanism is inactive (or not installed). The maxTool and options parameters are loaded into nvRAM in the TLAUF board as nibbles 4 and 5 (maxTool) and 6 (options). The load into the TLAUF is NOT automatically performed when the parameters are changed — a call to load TlAuf must be performed to update nvRAM.

The OPTIONS parameter is defined as follows:
Bit 3 = Input Polarity (0 = High active, 1 = Low active)
Bit 2 = not used
Bit 1-0 = Changer Type:
00 = Lightning (arm - air solenoid)
01 = 308 (arm - electric motor)
10 = spare
11 = spare

00000000000 ; 090 ; Tool-Changer #1 number of tools.
00000000000 ; 091 ; Tool-Changer #1 option flags.
00000000000 ; 092 ; Tool-Changer #1 orient position (milidegrees).
00000000000 ; 093 ; Tool-Changer #1 Z-Axis offset (CUM's).
00000000000 ; 094 ; Tool-Changer #2 number of tools.
00000000000 ; 095 ; Tool-Changer #2 option flags.
00000000000 ; 096 ; Tool-Changer #2 orient position (mili-degrees).
00000000000 ; 097 ; Tool-Changer #2 Z-Axis offset (CUM's).

The "MASTER PARAMETER" consists of 8 4-bit fields that are used by the BMDC software to index into subroutines for handling radically different implementations for the same function, such as electronic Vs air-motor spindle-speed control. The eight fields are:

Family:
- 00 - EZ-TRAK
- 01 - EXPLORER
- 02 - DISCOVERY
- 03 - FIXTURE
- 04-15 reserved

Spindle Type:
- 00 - NONE (EZ-TRAK)
- 01 - ELECTRONIC
- 02 - AIR MOTOR
- 03-15 reserved

Spindle Feedback:
- 00 - NONE (EZTRAK)
- 01 - DIGITAL ENCODER ON MOTOR
- 02 - DIGITAL ENCODER ON SPINDLE
- 03 - ANALOG from ADC #1
- 04 - ANALOG from ADC #2
- 05-15 reserved

Species:
- 00 - 15 define "species" within a family.

Fields 5 through 8 reserved

00305201152 ; 098 ; the "Master" configuration

The PositionAtHome registers define the positions to set the axes to (via SetPoint) after a FindHome operation. They are in CUMs and (usually) are the same as the most positive NORMAL travel limit (the limit registers are usually a few CUMs larger to allow for "jump" at power-up).

00076200000 ; 099 ; xPositionAtHome (25.0")
00030480000 ; 100 ; yPositionAtHome (12.0")
00000000000 ; 101 ; zPositionAtHome
00000000000 ; 102 ; wPositionAtHome
00000000000 ; 103 ; sPositionAtHome
00000000000 ; 104 ; height above tool-change (tool-holder height)
00000000555 ; 105 ; X-Axis Leadscrew Compensation
-0000001110 ; 106 ; Y-Axis Leadscrew Compensation
00000000000 ; 107 ; Z-Axis Leadscrew Compensation
00000000000 ; 108 ; W-Axis Leadscrew Compensation

These registers store the parameters used by the Spindle Power Limiter. Because more power may be available than is safe for the machine, code is included to reduce feedrate when safe power levels are exceeded.

00000000000 ; 109 ; Spindle Horsepower Limit (24.8 fmt)
00000000000 ; 110 ; RPM above which power limiter is active
00000000000 ; 111 ; Scale factor for current sensor input (24.8 fmt)

These parameters set the "Axis Run-Away" check's threshold. The run-away test measures the difference between desired velocity and actual velocity. Two metrics are adjustable; the percentage difference that is allowed and the time period (in 10 ms increments) that the difference must exceed the allowed difference before an alarm is posted.

00000001000 ; 112 ; Allowable Velocity Difference, in percent units.
00000000100 ; 113 ; Time that velocties may differ, in 10 ms units.

The following parameters are "unused" at this time...

00000000000 ; 114
00000000000 ; 115
00000000000 ; 116
00000000000 ; 117
00000000000 ; 118
00000000000 ; 119
00000000000 ; 120
00000000000 ; 121
00000000000 ; 122
00000000000 ; 123
00000000000 ; 124
00000000000 ; 125
00000000000 ; 126
00000000000 ; 127
00000000000 ; 128
00000000000 ; 129
00000000000 ; 130
00000000000 ; 131
00000000000 ; 132
00000000000 ; 133
00000000000 ; 134
00000000000 ; 135
00000000000 ; 136
00000000000 ; 137
00000000000 ; 138
00000000000 ; 139
00000000000 ; 140
00000000000 ; 141
00000000000 ; 142
00000000000 ; 143
00000000000 ; 144

```
00000000000   ; 145
00000000000   ; 146
00000000000   ; 147
00000000000   ; 148
00000000000   ; 149
```

The following "parameters" are actually the contents of LOGICAL, the machine state (switches and commands) as mapped onto a "logical" (machine- independent) bitmap. Access to them is provided to facilitate writing diagnostic aids, such as a switch-state monitor.

```
00000000000   ; 150 ; Machine Faults Byte
00000000000   ; 151 ; Axis Limits Byte
00000000000   ; 152 ; Auxiliary Limits Byte
00000000000   ; 153 ; Drive Faults Byte
00000000000   ; 154 ; Machine Status Byte
00000000000   ; 155 ; Home Switch Status Byte
00000000000   ; 156 ; Machine Options Status Byte
00000000000   ; 157 ; User Status Byte
00000000000   ; 158 ; Switch Status Byte #1
00000000000   ; 159 ; Switch Status Byte #2
00000000000   ; 160 ; Machine Command Byte #2
00000000000   ; 161 ; Machine Options Command Byte
00000000000   ; 162 ; User Command Bits Register
00000000000   ; 163 ; Spindle Command Byte
00000000000   ; 164 ; Spindle Status Byte
00000000000   ; 165 ; Commanded spindle speed (RPM)
00000000000   ; 166 ; Tool Changer #1 command register
00000000000   ; 167 ; Tool Changer Status
00000000000   ; 168 ; Tool Changer Control Register
00000000000   ; 169 ; Desired Current Tool position
00000000000   ; 170 ; Current Tool Carousel position
00000000000   ; 171 ; Inputs to TLAUF
00000000000   ; 172 ; TL1AUF output command register (for test use)
00000000000   ; 173 ; Desired NOVRAM address
00000000000   ; 174 ; Data to be written into NOVRAM
00000000000   ; 175 ; NOVRAM address
00000000000   ; 176 ; Register used by AUFDRVR to access NOVRAM
00000000000   ; 177 ; NOVRAM byte 00
00000000000   ; 178 ; NOVRAM byte 01
00000000000   ; 179 ; NOVRAM byte 02
00000000000   ; 180 ; NOVRAM byte 03
00000000000   ; 181 ; NOVRAM byte 04
00000000000   ; 182 ; NOVRAM byte 05
00000000000   ; 183 ; NOVRAM byte 06
00000000000   ; 184 ; NOVRAM byte 07
```

```
00000000000    ; 185 ; NOVRAM byte 08
00000000000    ; 186 ; NOVRAM byte 09
00000000000    ; 187 ; NOVRAM byte 10
00000000000    ; 188 ; NOVRAM byte 11
00000000000    ; 189 ; NOVRAM byte 12
00000000000    ; 190 ; NOVRAM byte 13
00000000000    ; 191 ; NOVRAM byte 14
00000000000    ; 192 ; NOVRAM byte 15
00000000000    ; 193 ; Tool Changer #2 command register
00000000000    ; 194 ; Tool Changer #2 Status
00000000000    ; 195 ; Tool Changer #2 Control Register
00000000000    ; 196 ; Desired Current Tool position
00000000000    ; 197 ; Current Tool Carousel position
00000000000    ; 198 ; Inputs to TLAUF
00000000000    ; 199 ; TL2AUF output command register (for test use)
00000000000    ; 200 ; Desired NOVRAM address
00000000000    ; 201 ; Data to be written into NOVRAM
00000000000    ; 202 ; NOVRAM address
00000000000    ; 203 ; Register used by AUFDRVR to access NOVRAM
00000000000    ; 204 ; NOVRAM byte 00
00000000000    ; 205 ; NOVRAM byte 01
00000000000    ; 206 ; NOVRAM byte 02
00000000000    ; 207 ; NOVRAM byte 03
00000000000    ; 208 ; NOVRAM byte 04
00000000000    ; 209 ; NOVRAM byte 05
00000000000    ; 210 ; NOVRAM byte 06
00000000000    ; 211 ; NOVRAM byte 07
00000000000    ; 212 ; NOVRAM byte 08
00000000000    ; 213 ; NOVRAM byte 09
00000000000    ; 214 ; NOVRAM byte 10
00000000000    ; 215 ; NOVRAM byte 11
00000000000    ; 216 ; NOVRAM byte 12
00000000000    ; 217 ; NOVRAM byte 13
00000000000    ; 218 ; NOVRAM byte 14
00000000000    ; 219 ; NOVRAM byte 15
00000000000    ; 220 ; Feedrate Override  (%)
00000000000    ; 221 ; Spindle speed pot.
00000000000    ; 222 ; X axis Joystick
00000000000    ; 223 ; Y axis Joystick
00000000000    ; 224 ; Z axis Joystick
00000000000    ; 225 ; W axis Joystick
00000000000    ; 226 ; S axis Joystick
; end of param file
```

### 7.4 Error Messages

| MESSAGE | MEANING |
|---|---|
| **** ALARM **** | This text is displayed in blinking white on a red background in the machine status window between DIA: and S,ACT (green window in the upper right corner of the display) when the machine is in an alarm state. To reset an alarm, hit the Escape key. If the alarm does not reset, call a service man. |
| All Parameters Set | The operator receives this message after he has finished re-loading the binary executive by selecting F9 in Startup. This message informs the operator that all machine parameters in the BMDC card have been set to the values in BMDCPRMS.SYS. |
| Attempt to write to a write-protected disk | An attempt was made to write a part program to a write-protected floppy disk. Check that the button on the back of the disk is set to the write position. |
| auxFuncs: Low Air Pressure | This message applies only to machines with electronic (automatic) and air-motor spindles. The operator receives this message when the air pressure is low. |
| auxFuncs: Low Lube Level | This message only applies to machines with air-motor and electronic (automatic) spindles. The operator receives this message when the lubrication level is low. |
| auxFuncs: Spindle Time-Out | This message only applies to machines with electronic (automatic) spindles. The operator receives this message because it took too long for a spindle command to be processed because the spindle control module is busy. If tapping was being done, the spindle and axis drive are turned off immediately after posting the message. If another operation was being performed, no action is taken after posting the message. |
| AXES must be HOMED to enable MENUS [ – ]!! Hit <any KEY> to CONTINUE | This message is displayed if the operator attempted to select BASIC menus from the Start Up Menu before homing the axes. |

| | |
|---|---|
| Axis Drive Fault | The operator receives this message whenever the axis drive fault bit has been set. The spindle and axis drives are turned off and the system is shut down. |
| Axis Drives OFF | This message appears whenever the machine starts to execute a commanded move and the axis drive system is off. |
| Bounds Fault | This message is displayed when a commanded (move would exceed limits) move exceeds the limits set by the maximum travel parameters. |
| (C) 1992 Bridgeport Machines, Inc. | This message informs the user that this software is copyrighted. It appears immediately following boot-up or a reset command (i.e. whenever the binary executive is loaded into the BMDC card). |
| Canceled by operator | This message is displayed when the operator presses the escape key in "4 Load Remote" from Startup Menus while attempting to send or receive a part program from a remote terminal. |
| Canceled by remote device | The operator receives this message in "4 Load Remote" from Startup Menus while attempting to send or receive a part program from a remote terminal. The link was canceled by the remote terminal. |
| Cannot Open Param File | The operator receives this message while attempting to re-load the binary executive (BMDC.BIN) file by selecting "F9 LDmdcSW" from the Startup Menu. This message is displayed while attempting to load the machine parameters from BMDCPRMS.SYS to the BMDC board. Check to make sure that the BMDCPRMS.SYS file exists and is in the bootup directory (i.e. the directory containing the CNC software). |
| Can't CLEAR when in RUN<br>Hit <any KEY> to CONTINUE | This message is displayed if the operator tries to "9 CLEAR CNC" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Can't EDT CNC when in DNC<br>Hit <any KEY> to CONTINUE | This message is displayed when, during DNC mode, the operator tries to "F2 EDT CNC" in "F4 RUN" from Basic Menus while the axes are in motion. |

| | |
|---|---|
| Can't FIND when in RUN | This message is displayed if the operator tries to "4 FIND : _N_T_" from Basic Menus while the axes are in motion. |
| Can't FIND when in RUN<br>Hit <any KEY> to CONTINUE | This message is displayed if the operator tries to "F6 FND :NT" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Can't HOLD now<br>will HOLD when done | This message appears when the HOLD button is pressed during a critical section of a tool change or plug reverse tapping cycle. It informs the user that it can only place the machine in a HOLD state after the cycle completes. |
| Can't JOG when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "9 JOG" from Basic Menus while the axes are in motion. |
| Can't LOAD when in RUN<br>Hit <any KEY> to CONTINUE | This message is displayed if the operator tries to load a part program from "F5 MDI" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Can't LOAD when in RUN<br>Hit <any KEY> to CONTINUE | This message is displayed if the operator tries to "F7 LOAD" from Basic Menus while the axes are in motion. |
| Can't LOAD when in RUN<br>Hit <any KEY> to CONTINUE | This message is displayed while attempting to load a part program into the BMDC card after selecting "F4 EDT CNC" in "F4 RUN" from Basic Menus while the axes are in motion. |
| !!! Can't LOAD when in RUN<br>Hit <any KEY> to CONTINUE | This message is displayed when attempting to select "F7 LOAD" in "F3 SETUP" while the axes are in motion. |
| Can't MDI when in DNC<br>Hit <any KEY> to CONTINUE | This message is displayed in DNC mode if the operator tries to "F5 MDI" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Can't MDI when in HOLD<br>Hit any key to continue\ | This message is displayed if the operator tries to "F5 MDI" in "F4 RUN" from Basic Menus while the HOLD button is pushed in. |
| Can't MDI when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "F5 MDI" in "F4 RUN" from Basic Menus while the axes are in motion. |

| | |
|---|---|
| Can't MDI when in RUN or HOLD<br>Hit any key to continue | This message is displayed if the operator tries to "6 S_T_M_" from Basic Menus while the axes are in motion. |
| Can't PREVIEW when in RUN | This message is displayed if the operator tries to "F5 PREVIEW" from Basic Menus while the axes are in motion. |
| Can't QUILL UP when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "F9 QU UP" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Can't QUILL UP when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "F9 QUILL UP" from Basic Menus while the axes are in motion. |
| Can't RESET when in RUN<br>Hit <any KEY> to CONTINUE | This message is displayed if the operator tries to "5 RESET PGM" from Basic Menus while the axes are in motion. |
| Can't RESET while in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "5 RESET PGM" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Can't SET DNC while in RUN<br>Hit <any KEY> to CONTINUE | This message is displayed if the operator tries to "F10 SET DNC" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Can't SET OPTIONS when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "7 SET OPTION" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Can't set params in HOLD!! | This message is displayed if the operator attempts to select "1 SET PARAMS" from startup while the HOLD button is pressed in. |
| Can't SET TNO when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "4 SET TNO" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Can't SET TNO when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "8 SET TNO" from Basic Menus while the axes are in motion. |

| | |
|---|---|
| Can't SET TOOLS when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "7 SET T\\" from Basic Menus while the axes are in motion. |
| Can't SETUP when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "F3 SETUP" from Basic Menus while the axes are in motion. |
| !!! Can't SETUP when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "F3 SETUP" from Basic Menus while the axes are in motion. |
| Can't SPINDLE/OFF when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "F2 S_/OFF" from Basic Menus while the axes are in motion. |
| Can't SPINDLE/OFF when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "F2 S_/OFF" in "F4 RUN" from Basic Menus while the axes are in motion. |
| !!! Can't STARTUP when in RUN | This message is displayed if the operator attempted to make a startup menu selection while the axes are in motion. |
| CENTER 3 PTS\| ERROR !! | This message appears when "6 CNTR 3 PTS" was selected in "F4 GEOM" from "9 JOG" in Basic Menus. Two or more of the points on the arc are the same point. |
| CENTER 3 PTS\| ERROR !!<br>[X, Y, or R > 999.]<br>Hit <any KEY> to CONTINUE | This message appears when "6 CNTR 3 PTS" was selected in "F4 GEOM" from "9 JOG" in Basic Menus. One or more of the X or Y coordinate values of a point is too large. |
| CENTER 3 PTS\| ERROR !!<br>Select I (inside) or O (outside)<br>Hit <any KEY> to CONTINUE | This message appears when "6 CNTR 3 PTS" was selected in "F4 GEOM" from "9 JOG" in Basic Menus. "I" for inside circle or "O" for outside circle must be inputted so that the cutter radius can be subtracted or added, respectively, to the circle radius value. |
| Cutter-Comp: Dummy Radius Won't Fit | This message occurs when the compensated offset from the cutting surface is less than the radius of the tool. |
| Cutter-Comp: Negative Radius | This message appears if a negative radius was specified within a cutter compensation block. |
| Disable Spindle prior to Enabling AxisDrives | The operator receives this message if he tries to turn on the axis drive system with the spindle running. |

| | |
|---|---|
| DNC file error – ABORTED | This message is displayed if a block of data could not be successfully read from the DNC part program file. Check media and make sure DNC file is not read protected. |
| DNC file error – ABORTED | The format of the DNC file is not compatible with the IBM PC file format. |
| DNC internal error – ABORTED | The operator receives this message if the DNC part program file could not be loaded into the BMDC card. Check that the format of the DNC part program file is IBM PC compatible and check the BMDC card. |
| DNC internal error – ABORTED | This message is displayed while running under DNC mode. DNC mode is used when the size of the part program to run is larger than 256K bytes. The operator receives this message because there was an error detected while writing a portion of the DNC file to the BMDC. Check the BMDC board. |
| DNC OFF? <Y><br>or <ESC>= CANCEL | The operator receives this message while running under DNC mode when "F10 DNC OFF" is selected from "F4 RUN" in Basic Menus. This message prompts the operator for confirmation before turning off DNC mode. DNC mode is unaffected if the <ESC> key is pressed. |
| dpCom: ADC Failure | An ADC test is performed immediately following power up. the axis command inputs to the ADC are examined. The inputs should be near ground because of the hardware reset. This message is displayed if the values are outside the +-6.25% allowable tolerance. |
| dpCom: Commanded X Axis Move Too Far Minus | This message is displayed when a commanded X move is less than the X axis negative limit of travel (parameter 17). The interpolator caught the error meaning that the machine has moved as far as it can in the negative X direction. |
| dpCom: Commanded X Axis Move Too Far Positive | This message is displayed when a commanded X move is greater than the X axis positive limit of travel (parameter 18). the interpolator caught the error meaning that the machine has moved as far as it can in the positive X direction. |
| dpCom: Commanded Y Axis Move Too Far Minus | |

| | |
|---|---|
| dpCom: Commanded Y Axis Move Too Far Positive | |
| dpCom: Commanded Z Axis Move Too Far Minus | |
| dpCom: Commanded Z Axis Move Too Far Positive | |
| dpCom: Commanded W Axis Move Too Far Minus | |
| dpCom: Commanded W Axis Move Too Far Positive | |
| dpCom: Commanded S Axis Move Too Far Minus | |
| dpCom: Commanded S Axis Move Too Far Positive | |
| dpCom: Invalid Command | This message appears because the front end user interface submitted an invalid command to the BMDC card. Some of the valid commands are: "home axes", "move command", "set param values", "set axis Jog command", etc. |
| dpCom: Low Air Pressure | This message applies only to machines with electronic (automatic) and air-motor spindles. The operator receives this message when the air pressure is low. |
| dpCom: Low Lube Level | This message only applies to machines with air-motor and electronic (automatic) spindles. The operator receives this message when the lubrication level is low. |
| dpCom: Must HOME AXES first | An axis move was attempted before the axes were homed. |
| dpCom: No Feedrate Specified | This message occurs when a GCODE block requires a feedrate and none was specified. Example: G1X2.Y3. will generate this message (G1 requires a feedrate). |
| dpCom: Program Buffer Overflow | This message appears because the size of the part program has exceeded 256K bytes. |

| | |
|---|---|
| dpCom: QDAC Failure | QDAC tests are performed immediately following power up. Each DAC (one for each axis) is loaded with 3 values. The DAC input register is then read to verify that the data was written. If the data in the DAC input register differs from the values written, then this message is displayed and the axis drive system is disabled. The output voltage is then read by the ADC. The expected values are (FF, 00, and 80 hex). The allowable absolute tolerance is (F8 – D0), (70 – 90), and (08 – 30) for the X, Y, Z, W axis DACs respectively. This message is generated when the output value read by the ADC is outside these tolerances. |
| dpCom: SDAC Failure | SDAC tests are performed immediately following power up. The SDAC is used to output analog command voltages to the spindle drive. The SDAC is loaded with 5 values. The SDAC input register is then read to verify that the data was written properly. This message is displayed when the data in the DAC input register differs from the values written. Test Failure also causes the axis drive system to be disabled. |
| Drive not ready | A floppy disk could not be found in drive A:\. Check that there is a floppy disk in the disk drive, that the disk is pressed in, and that the drive door is closed all the way. |
| ** DRIVES OFF ** | This message informs the operator that the axis drive system is off. The operator receives this message just after boot up, after a fatal error, or after a soft reset or after reloading the binary executive. |
| Emergency Stop Activated | This message is displayed whenever the emergency stop button is pushed in or whenever the user presses the emergency stop button. The user can not clear the message when in E-STOP. He must first pull out the E-STOP button and then clear the message by hitting the Escape key. |
| Enable Spindle FWD | This message applies only to machines that have manual spindles. It appears whenever the spindle has been commanded to rotate in the forward direction. It prompts the operator to set the spindle direction switch to forward and then turn the spindle on. |

| | |
|---|---|
| Enable Spindle HI | This message is displayed only on a lathe machine when spindle gear 2 (HI) (M12) is selected. The message prompts the operator to turn the spindle on. |
| Enable Spindle HI-CW | This message is used with machines that have air-motor (semi-automatic) spindles only. It appears when the commanded spindle RPM is in the HI gear range and the commanded spindle direction is clockwise. It informs the operator of the current switch settings and prompts him to turn the spindle on. |
| Enable Spindle HI-CCW | This message is used with machine that have air-motor (semi-automatic) spindles only. It appears when the commanded spindle RPM is in the HI gear range and the commanded spindle direction is counter clockwise. It displays the current spindle settings and prompts the operator to turn the spindle on. |
| Enable Spindle LO | This message is displayed only on a lathe machine when spindle gear 1 (LO) (M11) is selected. The message informs the user of his selection and prompts him to turn the spindle on. |
| Enable Spindle LO-CW | This message is used with machines that have air-motor (semi-automatic) spindles only. It appears when the commanded spindle RPM is in the LO gear range and the commanded spindle direction is clockwise. It displays the current switch settings and prompts the operator to turn the spindle on. |
| Enable Spindle LO-CCW | This message is used with machines that have air-motor (semi-automatic) spindles only. It appears when the commanded spindle RPM is in the LO gear range and the commanded spindle direction is counter clockwise. It displays the current spindle settings and prompts the operator to turn the spindle on. |
| Enable Spindle REV | This message applies only to machines that have manual spindles. It appears whenever the spindle has been commanded to rotate in the reverse direction. It prompts the operator to set the spindle direction switch to reverse and then turn the spindle on. |

| | |
|---|---|
| ERR: Failed to open | The operator receives this message while attempting to load a part program from a remote terminal (EZLINK) or from a remote terminal (XON/OFF) in "4 Load Remote" from Startup Menus. This message is displayed if the part program failed to open on the destination machine (machine operator is using). Check that the disk or diskette is not write protected (make sure that the button on the back of the diskette is set to the write position). |
| ERR – – Illegal Baudrate | This is displayed if the baud rate to send/receive file in "4 Load Remote" from Startup Menus is not one of the following values (110, 300, 600, 1200, 2400, 4800, 19200, 38400). |
| ERR – – link error – aborted | This message is displayed in "4 Load Remote" from Startup Menus while attempting to link up with a remote terminal. The operator receives this message if the MODEM could not establish a link with the remote terminal. |
| ERR – – reading file – aborted | This message is displayed while attempting to send/receive a part program from a remote terminal. This message applies to the operator's end if we are sending a file and to the remote end if we are receiving. Check that the file exists. |
| ERR – – writing file – aborted | This message is displayed while attempting to send/receive a part program from a remote terminal. EZLINK or XON/OFF could not send/receive the entire file. Check disk space or disk write protection. |
| ERROR: Enter numeric data only !!<br>Hit <any KEY> | This message is displayed when the operator selects "F5 GOCLRPT" from "9 JOG" in Basic Menus and then enters invalid characters for the X, Y, Z, C coordinates of the clearance point. |
| ERROR: Enter numeric data only !!<br>Hit <any KEY> | This message is displayed when "SET X" is selected from "9 JOG" in Basic Menus and invalid characters are entered for the X coordinate value. |
| ERROR: Enter numeric data only !!<br>Hit <any KEY> | This message is displayed when "SET Y" is selected from "9 JOG" in Basic Menus and invalid characters are entered for the Y coordinate value. |

| | |
|---|---|
| ERROR in LOAD CNC!!<br>Hit <any KEY> | The operator receives this message when selecting "F7 LOAD" from Basic Menus. An error was detected while loading a part program into the BMDC card. The reason for this error could be: (1) Bad BMDC board, (2) Part program file is too large (>256K bytes), (3) Bad hard disk or floppy disk. |
| ERROR in LOAD CNC!!<br>Hit <any KEY> | This message is displayed when exiting teach mode (teach mode is selected from "9 JOG" in Basic Menus). When the operator selects "<+> ENTER/EXIT/REVIEW" (Enter to enter the last GCODE block into TEACH.TXT, EXIT to exit teach mode and load the teach program into the BMDC board, and REVIEW to edit TEACH.TXT). Reasons for this message include: (1) Teach program is too large (> 256K bytes), (2) Bad BMDC board, (3) Bad file format. |
| ERROR in Reading DISK!!<br>Hit <any KEY> | This message is displayed when exiting teach mode (teach mode is selected from "9 JOG" in Basic Menus). When the operator selects "<+> ENTER/EXIT/REVIEW" (Enter to enter the last GCODE block into TEACH.TXT, EXIT to exit teach mode and load the teach program into the BMDC board, and REVIEW to edit TEACH.TXT). Check for room on the hard disk. |
| ERROR in Reading DISK!!<br>Hit <any KEY> | This message is displayed while attempting to load the DNC part program file during "F10 SET DNC" from "F4 RUN". It could not open the DNC part program file. check that the DNC part program file exists. |
| ERROR in Reading DISK!!<br>Hit <any KEY><br>Use START switch to validate MACROs, then Hit <any KEY> to continue | This message is displayed while attempting to load in the DNC macros file during "F10 SET DNC" from "F4 RUN". The operator receives this message if the DNC macros file could not be opened. The operator receives this message if the DNC part program file could not be opened. Check that the DNC macros file exists. |
| ERROR in Reading TEACH.TXT !!<br>Hit <any KEY> to CONTINUE | This message is displayed when the operator selects "EDIT TEACH" while in teach mode from "9 JOG". The front end software could not open the file TEACH.TXT. Make sure that TEACH.TXT exists and is located in the root directory. |

| | |
|---|---|
| Error Reading Param File | This message occurs while reading the machine parameter file values for downloading to the BMDC card. The operator receives this message if the Parameter file revision number could not be found or the parameter file contains too many parameters for the current version of the software to handle. |
| Error: Spindle Not On | This message appears if the Spindle is off when a move is in progress that requires the spindle to be on. |
| Error while reading. File may be corrupt | This message is displayed when configuration file information could not be found. Check media and check the format of the configuration file (see "Unexpected EOF. File may be corrupt" message). |
| Executive Load...<br>FAILED to open file \<br>hit any key | The operator receives this message while attempting to re-load the binary executive (BMDC.BIN file) by selecting "F9 LDmdcSW" from the Startup Menu. Make sure BMDC.BIN is in your bootup directory (i.e. C:\BMDC.BIN or A:\BMDC.BIN). |
| EXIT \|\| ERROR in writing FILE !!<br>Hit <any KEY> to continue | This message is displayed while attempting to write a part program to disk or diskette after exiting the editor. Possible reasons for this message could be disk or diskette full. |
| FAILED – BMDC did not start | The front end software waits 20 seconds for the binary executive to load and for the BMDC card to come on line. This message is displayed if the BMDC card takes longer than 20 seconds. Check the BMDC card. |
| FAILED – Error reading binary image file! | An error was detected while reading in the "BMDC.BIN" file. The contents of the file may be corrupt or the boot disk may be bad. |
| FAILED – Error reading file! | The operator receives this message while attempting to load the binary executive (BMDC.BIN file) into the BMDC card. Check the boot drive. |
| FAILED – File too large! | This message is displayed if the size in bytes of the BMDC.BIN file has exceeded 256K. |

| | |
|---|---|
| FAILED to open file | Just after boot-up the information in the binary executive file is read and then loaded into the BMDC card. This message is displayed if the binary executive file "BMDC.BIN" could not be located. Check that the BMDC.BIN file exists. |
| Hit START when ready | This message only applies to Discovery class machines with automatic tool changers. It appears immediately following a tool change operation. It informs the user that the tool change operation has completed and that the machine is ready to execute the next GCODE block. |
| Illegal M-Code | This message is displayed when an unknown M-Code has been encountered. |
| INCOMPATIBLE SOFTWARE VERSIONS DETECTED<br>You MUST RE-LOAD the executive software by selecting <F9>, LDmdcSW from the initial menu.<br>HIT ANY KEY to clear this message<br>– – Hit Any Key to return to DOS – –<br>[%s bytes free = %ld] | The operator receives this message when the version of the binary executive software is not supported by the hardware or front end software. |
| INCOMPATIBLE SOFTWARE VERSIONS DETECTED<br>You MUST RE-LOAD the executive software by selecting <F9>, LDmdcSW from the initial menu.<br>HIT ANY KEY to clear this message | The operator receives this message while attempting to re-load the binary executive (BMDC.BIN file) by selecting "F9 LDmdcSW" from the Startup Menu. Software versions of the binary executive below 2.27 are not compatible with the current front end software and BMDC board. Try re-loading the executive software. If the message persists, contact BMI applications and get an update disk containing the latest software. |
| [INSERT NEW DISK!!]<br>Hit <any KEY> to continue | This message is displayed while attempting to write a part program to disk or diskette after exiting the editor. Possible reasons for this message could be disk or diskette full. |
| INTOF 2LNS! ERROR !!<br>2 points are same for a line<br>Hit <any KEY> to CONTINUE | The operator receives this message when he selects "9 INTOF 2 LN" in "F4 GEOM" from "9 JOG" of Basic Menus. Check that the starting and ending points for line 1 or line 2 are different. |

| | |
|---|---|
| Insufficient Lube Pressure | This message only applies to machines that have electronic (automatic) or air-motor spindles. It appears when the lube pressure is low. |
| **LIMIT** | This message is displayed in the machine status window (green window in the upper right corner of the display across from the XABS, YABS, ZABS labels) when the X, Y, Z, W coordinate positions have exceeded the max. travel limits (params 31, 32, 33). |
| Low Air Pressure – Cannot Set Speed | This message only applies to machines with air-motor spindles. It appears when the spindle speed has been changed via encountering an "S" command in a part program or by "6 STM" from Basic menus. It occurs because the air pressure generated by the air motor solenoid is too low to change the spindle speed. |
| MIDPT 2PTSl ERROR !! Select I (inside), O (outside) or N (none)<br>Hit <any KEY> to CONTINUE | This message appears when "8MID PT 2 PTS" was selected in "F4 GEOM" from "9 JOG" in Basic Menus. "I" for inside circle or "O" for outside circle or "N" for no offset must be inputted so that the cutter radius can be added or subtracted, respectively, from the mid point. |
| No Feedrate Specified | This message is displayed when a GCODE block (or rate of zero) requires a feedrate and none was specified. Example: G1X2.Y3. will generate this message (G1 requires a feedrate). |
| NO FILES in DIRECTORY !!<br><F2>= EXIT, or <ENTER>= NEW PATH | This message appears during a file selection operation (in F7 Make New Directory or F8 Change Working Directory from 5 FILES in Startup Menus) when the current working directory (usually the directory containing the startup software) has no part program files (files with extension ".TXT"). It gives the user the option of changing the current working directory. Once the path has been changed, all part program files in the new working directory will be displayed. |
| NO FILES in DIRECTORY !!<br><F2>= EXIT,<br><ESC>= CANCEL or<br><ENTER>= NEW FILE | This message appears during a file selection operation (from "5 FILES" of Startup Menus, "EDIT CNC" in "F4 RUN", or "F6 EDIT" in Basic Menus) when the current working directory (usually the directory containing the startup software) has no part program files (files with extension ".TXT"). It gives the operator the option of exiting file selection or typing in a file specification to select from. |

| | |
|---|---|
| NOT HOMED | This message is displayed in the machine status window (green window in the upper right corner of the display across from the XABS, YABS, ZABS labels) before the axes have been homed. Once "8 Home Axes" has been invoked, these values will display the user offset values of the current spindle position. |
| NOT RUNNING | This message is displayed just after bootup or when re-entering by typing run at the DOS prompt if the BMDC is not currently up and running. |
| OPTIONS cannot be set when in RUN<br>Hit any key to continue | This message is displayed if the operator tries to "7 SET OPTIONS" in "F4 RUN" from Basic Menus while the axes are in motion. |
| Orient Tool, Hit AUTO/BLOCK, START | This message applies to machines with manual (non-orientable) spindles only. It occurs when processing an M19 "Spindle Orient" command. It prompts the user to manually move the tool to the desired orient position. Note: Check parameter 92 – Tool Change #1 Orient Position (millidegrees). |
| Parser: #1 Internal Addressing Error | This message is displayed when the number of nesting levels in a user macro has exceeded 4. Example of nesting: When macro B is called from within macro A, macro A has a nesting level of 0 and macro B has a nesting level of 1. If B calls C which in turn calls D which in turn calls E, then C, D, E have nesting levels of 2, 3, 4 respectively. |
| Parser: #2 Internal Addressing Error | This message is displayed when the number of user macro definitions has exceeded 99. |
| Parser: #3 Internal Addressing Error | This message is displayed when the number of nesting levels in a user macro has exceeded 4. |
| Parser: #4 Internal Addressing Error | This message is displayed when trying to jump to an invalid canned cycle label. Valid canned cycle labels are numbered 0 – 11. |
| Parser: #5 Internal Addressing Error | This message is displayed when the label number in an "L" label command is not in the range 1 – 9. An "L" label command occurs when the first character in a GCODE block is an "L" and the second character is a digit (1 – 9). |

| | |
|---|---|
| Parser: #6 Internal Addressing Error | This message is displayed when calling an invalid canned cycle. Valid canned cycles are in the range G81 – G89, G170 – G176, G181 – G189, G191 – G199. This message occurs when the specified name is outside this range. |
| Parser: #7 Internal Addressing Error | This message is displayed when the number of nesting levels for a canned cycle has exceeded 4. |
| Parser: #8 Internal Addressing Error | This message is displayed when the number of loop nesting levels has exceeded 4. |
| Parser: #9 Internal Addressing Error | This message is displayed when the label number on a =Ln (jump to Ln) statement is not a single digit in the range 1 – 9. |
| Parser: #10 Internal Addressing Error | This message is displayed when the label number in an "L" label command is not in the range 1 – 9. An "L" label command occurs when the first character in a GCODE block is an "L" and the second character is a digit (1 – 9). |
| Parser: #11 Internal Addressing Error | This message is displayed when the number of nesting levels in a user macro has exceeded 4. Example of nesting: when macro B is called from within macro A, macro A has a nesting level of 0 and macro B has a nesting level of 1. If B calls C which in turn calls D which in turn calls E, then C, D, E have nesting levels of 2, 3, 4 respectively. |
| Parser: #12 Internal Addressing Error | This is displayed when the macro number is less than zero or greater than 99 following the pound (#) sign in a user macro definition. |
| Parser: #13 Internal Addressing Error | This message is displayed when the number of nesting levels for system macros has exceeded 4. |
| Parser: #14 Internal Addressing Error | This message is displayed when the number of loop nesting levels has exceeded 4. |
| Parser: #15 Internal Addressing Error | Specified tool number is invalid. Valid tool numbers are in the range 1 – 24. |
| Parser: #16 Internal Addressing Error | An invalid variable index has been encountered. A variable name consists of a letter, A – Z, followed by a variable index, 1 – 9. A valid variable index must be a positive single digit number without a decimal point. |

| | |
|---|---|
| Parser: Bad Arc Radius Or Endpoint | This message is displayed when a negative radius is specified in a GCODE block. |
| Parser: Call Of Undefined Loop Or Macro | A sequence number was referenced in an =N loop call that does not exist or a label was referenced in an =L label call that does not exist or a macro number was referenced in an =# or =% that does not exist. |
| Parser: Cannot Comp "C" Axis | This message occurs when a C axis move or cut command appears between a G41 or G42 and a G40. |
| Parser: Commanded S Axis Move Too Far Minus | This message is displayed when a commanded S move is less than the S axis negative limit of travel (parameter 24). |
| Parser: Commanded S Axis Move Too Far Positive | This message is displayed when a commanded S move is greater than the S axis positive limit of travel (parameter 25). |
| Parser: Commanded W Axis Move Too Far Minus | This message is displayed when a commanded W move is less than the W axis negative limit of travel (parameter 22). |
| Parser: Commanded W Axis Move Too Far Positive | This message is displayed when a commanded W move is greater than the W axis positive limit of travel (parameter 23). |
| Parser: Commanded X Axis Move Too Far Minus | This message is displayed when a commanded X move is less than the X axis negative limit of travel (parameter 17). The parser caught the error before the commanded move started. |
| Parser: Commanded X Axis Move Too Far Positive | This message is displayed when a commanded X move is greater than the X axis positive limit of travel (parameter 18). The parser caught the error before the commanded move started. |
| Parser: Commanded Y Axis Move Too Far Minus | This message is displayed when a commanded Y move is less than the Y axis negative limit of travel (parameter 19). The parser caught the error before the commanded move started. |

| | |
|---|---|
| Parser: Commanded Y Axis Move Too Far Positive | This message is displayed when a commanded Y move is greater than the Y axis positive limit of travel (parameter 19). the parser caught the error before the commanded move started. |
| Parser: Commanded Z Axis Move Too Far Minus Z | This message is displayed when a commanded move is less than the Z axis negative limit of travel (parameter 20). The parser caught the error before the commanded move started. |
| Parser: Commanded Z Axis Move Too Far Positive | This message is displayed when a commanded Z move is greater than the Z axis positive limit of travel (parameter 21). |
| Parser: Illegal Condition Code | This message is displayed when the relational operator in a conditional test data block is unknown or invalid. Valid relational operators are: <GE>, <GT>, <LE>, <LT>, <EQ>, <NE>. The format of a conditional test data block is: ?A_<rel. op.> B_ where A_ is the variable to be tested against B_. |
| Parser: Illegal G-Code | This message is displayed when an unknown GCODE has been encountered. |
| Parser: Loops And Macros Illegal in DNC | This message is displayed during DNC mode when a macro definition block is encountered. Macro definitions are illegal in DNC mode. |
| Parser: No Feedrate Specified | This message occurs when a GCODE block requires a feedrate and none was specified. Example: G1X2.Y3. will generate this message (G1 requires a feedrate). |
| Parser: Syntax Error: Too Many Digits | A numeric string in a Parser line has exceeded the maximum number of digits allowed (17 digits). A numeric string can have the following symbols: "+ - . 0 1 2 3 4 5 6 7 8 9". |
| PPPL: Bad destination variable letter | This message is generated when a PPPL assignment statement does not begin with an alphabetic character (PPPL assignment statements must begin with a variable name and the name must start with an alphabetic character). |

| | |
|---|---|
| PPPL: Bad destination variable index | This message is posted when the first character in a PPPL assignment statement was an alphabetic character (variable name encountered) and the second character is not a numeric character (The first character of a variable name must be an alphabetic character and the second character of the name must be a numeric character). |
| PPPL: Bad PI | This message appears because PI was not found following a #. |
| PPPL: Cannot find equals sign | This message is generated if the first character in a PPPL statement is a letter and the second character is a digit (0 – 9) ( indicating a variable name) but the third character in a PPPL statement is not an Equal sign (must be a PPPL assignment statement). PPPL assignment statements must begin with a variable name followed by an equal sign. |
| PPPL: Expected Operator | This message appears when a missing operator is encountered or an invalid operator was specified in an assignment statement. An operator can appear between two variable names, a variable name and a constant, or 2 constants. Valid operators are "+" for addition, "-" for subtraction, "*" for multiplication, and "/" for division. |
| PPPL: Improper Function call | This message is displayed when a variable name or function call was expected but invalid PPPL characters for a variable name or subroutine call were found. |
| PPPL: Syntax Error-Parsed past End of Line | This message occurs when parsing a part program line. A character was expected but the end of the line was encountered. In other words, a premature end of line occurred. |
| PPPL: Syntax Error: Missing Value | This message occurs when parsing a part program line. More information was expected but the end of the line was encountered. In other words, a premature end of line occurred. |
| PPPL: Syntax Error: Too Many Digits | A numeric string in a PPPL line has exceeded the maximum number of digits allowed (17 digits). A numeric string can have the following symbols: "+ - . 0 1 2 3 4 5 6 7 8 9". |

| | |
|---|---|
| PPPL: 2-Argument Functions Require Parentheses | This message is displayed if a parenthesis is missing around the arguments of a two argument trig function. |
| PPPL: User IO but User AUF not operating | This message is displayed if the user AUF is not installed or operating properly. |
| Probe Fault (unexpected touch) | This message only applies to a machine with a probe in the spindle. It appears when an unexpected probe hit was encountered. It occurs when the probe is moving but not probing and the probe senses a touch. Upon sensing the touch, the probe will stop moving immediately (a safety feature). |
| Probe Installed – Spindle Denied | This message appears when a commanded M3 or M4 is encountered in a part program or the user tries to turn the spindle on via "6 STM" from Basic menus. It informs the user that spindle commands are not allowed when a touch probe has been installed. |
| rdParamFile ( ) returned return-code Internal Error | This message is displayed if the rdParamFile ( ) function has been modified and the function that calls the rdParamFile ( ) function has not been updated to reflect the change. This is an internal software problem. Contact BMI applications. |
| Read fault | An error was detected while reading from a floppy or hard drive. Run a diagnostic test on the floppy or hard disk. |
| Re-Load Tools | This message is displayed on machines with automatic tool changers when the tool changer becomes disoriented. A typical example of this is when the guard doors are opened during a tool change operation. When this message is displayed the operator must: (1) Re-Home the machine by selecting "8 HOME AXES" from the Startup Menu, (2) Home the tool changer magazine by selecting "6 TOOL CHANGE" in the Startup Menu and then selecting "2 HOME MAGAZINE". |
| REMOVE SYSTEM DISK and INSERT BLANK DISK BEFORE FORMATTING Hit <any KEY> to continue or <ESC> to exit | This message reminds the operator to remove the system disk from the floppy drive and insert the blank disk to be formatted. |

| | |
|---|---|
| rev version-number required!<br>Wrong Param File Version | This message is displayed when the machine parameter file is not compatible with the current front end software. Run the update program to make the parameter file current. |
| SAVE AS \|\| ERROR in naming FILE !!<br>SAVE TO OLD FILENAME? Y/N | This message is displayed when the operator selects "<S> = SAVE AS NEW FILE" to exit "F6 EDIT" from Basic Menus or to exit "F4 EDIT CNC" in "F4 RUN" from Basic Menus or to exit "F2 EDIT TEACH" program from "9 JOG" in Basic Menus and then hits the escape key to cancel instead of selecting a file name or typing in a new file name. This message gives the user the option of saving to the old file name or exiting without saving. |
| Servo: S DAC Overflow | An S overflow condition exists that causes the S DAC to become saturated, meaning control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |
| Servo: S DAC Underflow | An S underflow condition exists that causes the S DAC to become saturated, meaning control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |
| Servo: W DAC Overflow | A W DAC overflow condition exists that causes the W DAC to become saturated, meaning control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |
| Servo: W DAC Underflow | A W underflow condition exists that causes the W DAC to become saturated, meaning control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |
| Servo: X DAC Overflow | An X overflow condition exists that causes the X DAC to become saturated, meaning control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |

| | |
|---|---|
| Servo: X DAC Underflow | An X underflow condition exists that causes the X DAC (Digital to Analog Converter) to become saturated, meaning control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |
| Servo: Y DAC Overflow | A Y overflow condition exists that causes the Y DAC to become saturated, meaning control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |
| Servo: Y DAC Underflow | A Y underflow condition exists that causes the Y DAC to become saturated, meaning that control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |
| Servo: Z DAC Overflow | A Z overflow condition exists that causes the Z DAC to become saturated, meaning control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |
| Servo: Z DAC Underflow | A Z underflow condition exists that causes the Z DAC to become saturated, meaning control of that axis has been lost. When this discrepancy is detected and then persists for 150ms, an alarm condition is generated, this message is displayed, and the axis drive system is shut down. |
| setParameter (parameter -number) FAILED! Error Setting Parameter | This message is displayed if the front end software failed to set a machine parameter in the BMDC to a specific value or the BMDC got hung up. Check the BMDC board. |
| Speed not valid in ANY gear | This message occurs on machines with air-motor or electronic spindles when the commanded spindle speed is too high or low for the spindle motor or belt to handle. |

| | |
|---|---|
| Spindle Motor Over-Heated | This message is displayed when the spindle load has caused the motor to overheat. |
| Spindle Motor Overload | This message occurs when the load on the spindle is too large for the spindle motor to handle. |
| Spindle Not On – Cannot Cut | This message appears on machines with air-motor or electronic spindles during RUN (AUTO or BLOCK) because the user did not put a spindle on "S" command before a command milling or drilling operation in a part program or because the user tried to MDI (DO EVENT) a milling or drilling operation before turning the spindle on. |
| Spindle Speed Too High | This message applies only to machines that have air-motor (semi-automatic) spindles. It appears when the commanded spindle speed is too low for even the low gear to handle. It displays the current spindle settings and prompts the operator to turn the spindle on. |
| Spindle Speed Too Low | This message applies only to machines that have air-motor (semi-automatic) spindles. It appears when the commanded spindle speed is too low for even the low gear to handle. It displays the current spindle settings and prompts the operator to turn the spindle on. |
| Spindle: Spindle Error | Spindle time out. The software waits 450 milli-seconds for the spindle drive to enable. This message is displayed if the spindle did not turn on during the wait interval. |
| Spindle Stalled | This message appears when the actual spindle slip percentage is greater than the max Limit (parameter 53). |
| System: C-Axis Run-Away | If the C encoder or DAC fails, a large discrepancy between the Commanded and actual velocities will develop. When this discrepancy persists for a pre-determined period of time, this message is posted, an alarm condition is generated, and the axis drive system is shut down. |
| System Communication Error from AUF | This message occurs when the number of errors on packets from the AUF has exceeded the MAX. |
| System Communication Error to AUF | This message occurs when the number of errors on packets to the AUF has exceeded the MAX. |

| | |
|---|---|
| System Communication Error from TLAUF | This message is displayed when the number of errors on packets from tool changer #1 AUF or tool changer #2 AUF has exceeded the maximum. |
| System Communication Error to TLAUF | This message is displayed when the number of errors on packets to tool changer #1 AUF or tool changer #2 AUF has exceeded the maximum. |
| System: S-Axis Run-Away | If the S encoder or DAC fails, a large discrepancy between the Commanded and actual velocities will develop. When this discrepancy persists for a pre-determined period of time, this message is posted, an alarm condition is generated, and the axis drive system is shut down. |
| System: X-Axis Run-Away | If the X encoder or DAC fails, a large discrepancy between the Commanded and actual velocities will develop. When this discrepancy persists for a pre-determined period of time, this message is posted, an alarm condition is generated, and the axis drive system is shut down. |
| System: Y-Axis Run-Away | If the Y encoder or DAC fails, a large discrepancy between the Commanded and actual velocities will develop. When this discrepancy persists for a pre-determined period of time, this message is posted, an alarm condition is generated, and the axis drive system is shut down. |
| System: Z-Axis Run-Away | If the Z encoder or DAC fails, a large discrepancy between the Commanded and actual velocities will develop. When this discrepancy persists for a pre-determined period of time, this message is posted, an alarm condition is generated, and the axis drive system is shut down. |
| TlChg: Drawbar Timeout | The operator receives this message when the tool-in-spindle did not unclamp or when the carousel did not clamp over the old tool during the "put-away" portion of a tool change operation or when the tool in the carousel did not unclamp or when the spindle did not clamp over a new tool during the "get" portion of a tool change operation. |
| TlChg: Invalid Switch States | Applies to machines with automatic tool changers only. This message will be displayed during a tool change operation while getting a tool from the carousel. It is displayed when a carousel or draw bar sensor failure occurs. |

| | |
|---|---|
| TlChg: NVRAM write error | This message is displayed when the non-volatile RAM on a TLAUF board is faulty. |
| TlChg: Tool-Arm Timeout | This message is displayed when the carousel did not extend to the spindle while putting away the old tool or inserting the new tool. It also appears when the carousel did not retract after putting the new tool in the spindle, after putting away the old tool or when the carousel did not home successfully. |
| TLAUF abort FAILED! | Whenever a failed event, such as an E-stop, occurs, the control sends an abort signal to the TLAUF (even if the TLAUF is not busy). The control then waits 100 milliseconds for the TLAUF to indicate that the abort command has been executed. This message is displayed if the TLAUF did not respond with an abort status within the 100 millisecond period. |
| Turn Off Spindle | This message appears only on a lathe when an M5 "Spindle Off" command is issued. |
| Turn On Spindle to Enable Run | The operator receives this message on a lathe or a milling machine with a manual spindle during RUN (AUTO or BLOCK) because a spindle on "S" command did not appear before a commanded cutting operation in a part program or because the part programmer tried to MDI (DO EVENT) a cutting operation before turning the spindle on. |
| Turn Spindle On In 1st Gear hit START when ready | This message applies only to machines with air-motor (semi-automatic) spindles. It appears when the commanded spindle speed is in the range of gear1 (low gear) (less than the Spindle-Range #1 Max (param. 74)). It prompts the user to set the knob to low gear and then to turn the spindle on. |
| Turn Spindle On In 2nd Gear hit START when ready | This message applies only to machines with air-motor (semi-automatic) spindles. It appears when the commanded spindle speed is in the range of gear 2 (high gear) (less than the Spindle-Range #1 Max (param. 74)). It prompts the user to set the knob to high gear and then to turn the spindle on. |
| Unexpected EOF. File may be corrupt | This message is displayed just after booting up while reading the configuration file (cfgprms.sys) contents. The operator receives this message when there is data missing |

| | |
|---|---|
| | from the configuration file. If there is a problem loading the configuration file, a default will be created, This means that all TLOs and offsets will need to be re-established. |
| USE <JOG SELECTOR SW> OR <JOG KNOB> TO MOVE AXES OFF UNEXPECTED POSITION | The operator receives this message if he selected "3 JOGOFF Limits" from the Startup Menu. This message informs the operator to turn the +- Jog Select Switch on the front panel to select the direction to jog, then push the +- Jog Select Switch to jog the selected axis and to use the rotary switch to move in finer increments. |
| WAIT – – AXIS HOMING!!<br>AXIS DRIVES NOT ENABLED !!! | This message is displayed if the operator selects "8 HOME AXES" before selecting "7AXIS DRV ENABLE" from the startup menu. |
| WAIT – – POSITIONING Z-AXIS | The operator receives this message if he attempts to enter a command while moving the Z axis to the tool change height after homing the tool change magazine. |
| waiting for BMDC | This message is displayed while attempting to load the binary executive into the BMDC card. This message informs the user to wait for the binary executive to finish loading and for the BMDC to come on line. |
| WARNING !!! FILE DID NOT WRITE:<br>CHECK ROOM ON DISK.<br>Loading . . .<br>FAILED-File too large! | The operator receives this message while attempting to load the binary executive (BMDC.BIN file) into the BMDC card. This message is displayed if the size of the BMDC.BIN file exceeds 256K bytes (262,144 bytes). |
| Write fault | An error was detected while writing to a floppy or hard drive. Run a diagnostic test on the floppy or hard disk. |
| [WRITE PROTECT] SOURCE DISK BEFORE COPYING<br>NOTE: diskcopy will require swapping SOURCE and TARGET disks several times<br>Hit <any KEY> to continue<br>or <ESC> to exit | This message informs the operator to slide the latch on the diskette to the write protect position so that the information on the source disk will not get corrupted. |

# CHAPTER 8. Tests

**Information for "Tests" is included in Chapter 7.**

# CHAPTER 8. Preventive Maintenance

## 8.1 INTRODUCTION

This chapter is written for operators or designated customer representatives. The operator must know how to operate the machine, monitor the levels of pneumatic oil, lubricating oil and coolant reservoirs, and recognize problems that require Dealer or Bridgeport Field Service maintenance. Most operator tasks deal with the external machine; however, the operator should be able to locate the overload heater reset in the Power Equipment Enclosure if necessary.

The operator is not authorized to make adjustments or replace components.

## 8.2 OVERVIEW

Maintenance procedures required for proper upkeep of the machine are included in the following pages. The charts in this section are geared to two types of operating conditions. Follow the chart that applies to your operating conditions. Section 9.4 explains each procedure in detail.

Operating conditions are defined as follows:

1. REGULAR SHIFT: The machine is used eight hours a day, five days a week.
2. MULTIPLE SHIFT: The machine is used in a three shift operation, five or more days a week.

A third operating condition is DRY CUTTING. In this case, the machine is used to cut materials such as cast iron, magnesium or carbon that produce unusually large amounts of dust in the air. This cutting could take place in either REGULAR or MULTIPLE SHIFT conditions. This is considered to be a HOSTILE environment which requires more than the average amount of care.

If the workpiece is cut dry, you must take extraordinary precautions, both while cutting and in cleanup to prevent dust and air from entering the system. Follow the maintenance procedures recommend for your shift conditions. In addition, use the following guidelines:

1. The cooling system in the head drives air into the system from behind the speed indicator plate. That air inlet should be filtered. This filtering system is not standard equipment supplied by Bridgeport and must be constructed by the machine owner.
2. Use an industrial vacuum cleaner and clean the exterior of the machine frequently. Do not use compressed air hoses to clean the machines.
3. Use specially designed vacuum systems at the cutting tool.
4. Use electrostatic filters if clean air cannot be directed to the head or the control cabinet inlets.

## 8.3 EQUIPMENT AND SUPPLIES

- Dry rags or paper cleaning cloths.
- Brush to sweep chips from the tables and ways.
- Industrial vacuum cleaner.
- Mobil DTE 24 or DTE light oil (for pneumatic system filter regulator)
- Coolant fluid. Bridgeport recommends Trim Sol or comparable antibacterial emulsified cutting oil.
- Lubricant for the way lubrication system. The following way lubricants are approved for use in this system:
  Gulfway 68
  Sunoco Way Lubricant 1180
  Mobil Vactra Oil No. 2
  Way Lubricant 68 (Texaco)
  Tonna 68 (Shell)

## 8.4 DESCRIPTION OF MAINTENANCE PROCEDURES

1. Check lube system oil level; fill if necessary. The most convenient procedure is to keep the level of oil to the top of the tank. Check it every day. If the reservoir is allowed to empty, a liquid level switch at its base shuts down the power to the spindle.

**WARNING**

Do not use compressed air to clean the ways or around the cabinets. Using compressed air could blow chips and other foreign material into the interlocking parts, control system, or at the operator, resulting in extensive damage or serious personal injury.

2. Clear dirt and chips from the ways at the end other day. Use a brush and/or an industrial wet or dry vacuum cleaner, then wipe carefully to remove damage-causing abrasive material. Do not use compressed air to clean the ways.
3. Clean machine exterior; clear intakes and exhausts. Clear dirt and chips from machine at the end of the day Use an industrial wet or dry vacuum cleaner, then wipe carefully to remove damage-causing abrasive material. Do not use compressed air to clean the machine.

**NOTE**

Check the air intakes and exhausts; clear any obstructions. Foreign materials in these areas can cause damage to the machine by entering the Control Power Enclosures.

4. Clean and apply a light coat of oil to the way covers once a week to keep them pliable.
5. Check coolant level; fill if necessary.

   **Flood Coolant:** Keep hose joint areas free of chips and dirt. The coolant will come out of the nozzle in spurts when the level is too low. Fill with Trim Sol or comparable antibacterial emulsified cutting oil.

   **Mist Coolant:** Wipe off excess grime from the top of the coolant reservoir periodically. It is recommend filling it only with the amount to be used in one operation.
6. Clean the air filters. When you can no longer see light through them, replace them. Dirty shop air can cause damage to the control system if not filtered properly.

**NOTE**

If mist coolant is used on this or on nearby machines, it will be necessary to change the filter frequently.

Keep the air filters clean to help prevent problems. Watch the air filters for the first few months of operation in order to get an idea of how often they should be replaced. The time between filter changes cannot be predicted because depends on many things, including hours of operation per day and the nature of materials being machined in the vicinity.

7. Check pneumatic regulator system bowls; fill lubricator bowl if necessary. When the level drops below the EMPTY line, fill to FULL with Mobil DTE 24 or direct equivalent.
   a. Shut off the air pressure.
   b. Remove the screw from the fill hole at the left rear of the lubricator.
   c. Fill the bowl to the FULL line. Do not overfill.
   d. Replace the fill hole screw.
8. Drain and clear refill pneumatic regulator bowls. The bowl should be drained whenever it fills up with sludge. The bowls should be cleaned semiannual.
   a. Put a dry rag under the regulator to catch the drips.
   b. Drain the filter bowl by pressing up on the drain valve.

To clean the bowls:
   a. Drain the filter bowl.
   b. Gently unscrew both bowls.

**WARNING**

Use only warm water to clean the filter bowls. Using soap, solvent, or chemicals may weaken the bowl and cause it to burst, resulting in serious personal injury.

c. Rinse them with WARM WATER only. Do not use soap.
d. Replace the bowls. Fill the lubricator with Mobil DTE 24 or direct equivalent. See step 7 in this section.

9. Check the spindle motor for dirt; wipe if necessary. The spindle motor can become overheated if excessive grease and dirt are allowed to build up on it.
   a. Remove spindle motor hood.
   b. Inspect the motor for dirt.
   c. Wipe the motor with a rag and remove as much of the build-up as possible.
   d. Replace the hood.
10. Check spindle drive belt for dirt and wear. Notify Dealer Service to replace it if necessary. If the housing itself is excessively dirty, the belt may be worn or weak.
    a. Remove the spindle drive belt cover.
    b. Inspect the belt for wear, cracks, or damage.
    c. If the belt looks worn, call Dealer Service to replace it.
    d. Replace the cover.
11. Remove and clean the automatic oil system pump filter.
12. Clean the dirt and chips from inside the Power Equipment Enclosure and around the card frame. Metal chips can come into contact with the boards and disrupt the electronic signals of the PC boards.

Check each item listed in the checklist (in your appropriate Operator Daily Maintenance Requirements Table) on a regular basis. Refer to the step numbers in this section (8.4) for an explanation of each numbered item on the checklist.

## 8.5 OPERATOR MAINTENANCE REQUIREMENTS

Refer to tables 8-1 and 8-2 (Operator Maintenance Requirements, Regular Shift and Multiple Shift, respectively).

Periodicity Codes:

D = Daily, performed on a daily basis during a 24 hour period.

W = Weekly, performed on a weekly basis.

M = Monthly, performed on a monthly basis.

S = Semiannual, performed twice a year.

AS REQ = Depends on working environment.

## 8.6 CLEANING PC CARDS

Printed circuit boards and wire-wrap boards require different cleaning procedures. Boards with trimmers or switches on them require special treatment. For printed circuit boards with switches or trimmers, use procedure 1. For wire-wrap boards, use procedure 2. For printed circuit boards without switches or trimmers, use procedure 3.

**CAUTION**

Use the correct method for cleaning each board. Do not use a compressed air hose on any of the boards. Failure to follow these cautions may result in damage to the boards.

Read the procedures in Appendix B on handling static sensitive boards before attempting to clean any boards. All the boards in the system are static sensitive and can be damaged if the safety procedures in Appendix B are not followed.

Assemble the following materials:

1. Mild liquid dishwashing detergent (JOY® recommended).
2. Soft brush.
3. Isopropyl alcohol (Miller-Stephenson MS 200™ Magnetic Tape Head Cleaner recommended).

# 8. Preventive Maintenance

### Procedure 1 — Boards with Trimmers and Switches

CAUTION

Use only the recommended cleaners and degreasers. Do not use water to clean these boards. Using water may ruin the boards.

1. Wash the boards down with MS 200™ (or isopropyl alcohol) and mild detergent alternately, using a soft brush to help loosen the grime.
2. Allow the boards to air-dry completely before inserting into system.

### Procedure 2 — Boards without Switches and Trimmers

CAUTION

Wash these boards quickly, then rinse them off. Do not immerse these boards in water or attempt to soak them. Doing so may ruin the boards.

1. Wash the board with a solution of JOY® and warm water, scrubbing gently with a soft brush to remove grime. Rinse thoroughly under running water.
2. Shake off as much water as possible.
3. Support the board in a vertical position with the edge connector at the top. Wash it down with MS 200™ or isopropyl alcohol, starting at the top and working down.
4. Allow the board to air-dry completely before reinserting into the system.

**Table 8-1.** Operator Maintenance Requirements - Regular Shift

| REF# | REQUIREMENT | PERIODICITY | | | | |
|---|---|---|---|---|---|---|
| | | D | W | M | S | AS REQ. |
| 1 | Check lube system oil level; fill if necessary | X | | | | |
| 2 | Clean dirt, chips from ways | X | | | | |
| 3 | Clean machine exterior; clear intakes and exhausts | | X | | | |
| 4 | Clean way covers; lightly oil | | X | | | |
| 5 | Check coolant level; fill if necessary | | X | | | |
| 6 | Check air filters; replace if necessary. Use electrostatic filters if dry cutting | | X | | | |
| 7 | Check pneumatic lubricator bowl; fill if necessary | | | X | | |
| 8 | Drain, clean, refill pneumatic filter bowl. See warnings | | | | X | |
| 9 | Check spindle motor for dirt; wipe if necessary | | | X | | |
| 10 | Check spindle drive belt for wear; notify Dealer Service to replace if necessary | | | X | | |
| 11 | Clean lube system pump filter | | | | X | |
| 12 | Clean inside control cabinet | | | X | | |

Check each item listed in the checklist on a regular basis. Refer to the step numbers in section 9.4 for an explanation of each numbered item on the checklist.

**Table 8-2.** Operator Maintenance Requirements - Multiple Shift

| REF# | REQUIREMENT | PERIODICITY | | | | |
|---|---|---|---|---|---|---|
| | | D | W | M | S | AS REQ. |
| 1 | Check lube system oil level; fill if necessary | X | | | | |
| 2 | Clean dirt, chips from ways | X | | | | |
| 3 | Clean machine exterior; clear intakes and exhausts | | | | | 48 hrs |
| 4 | Clean way covers; lightly oil | | | | | 48 hrs |
| 5 | Check coolant level; fill if necessary | | X | | | |
| 6 | Check air filters; replace if necessary. Use electrostatic filters if dry cutting | | | | | 48 hrs |
| 7 | Check pneumatic lubricator bowl; fill if necessary | | | X | | |
| 8 | Drain, clean, refill pneumatic filter bowl. See warnings | | | | X | |
| 9 | Check Tape for wear; replace if necessary | X | | | | |
| 10 | Check spindle drive belt for wear; notify Dealer Service to replace if necessary | | X | | | |
| 11 | Clean lube system pump filter | | | X | | |
| 12 | Clean inside control cabinet | | | | | 48 hrs |

Check each item listed in the checklist on a regular basis. Refer to the step numbers in section 8.4 for an explanation of each numbered item on the checklist.

## 8.7 AUXILIARIES SYSTEMS

Although section 8.4 itemizes the procedures to be followed, refer also to chapter 11 for further details.

# CHAPTER 9. Base Assembly

## 9.1 X AND Y-AXIS DRIVE MOTORS

### 9.1.1 X-Axis Drive Motor Removal (Figure 9-1)

DANGER

Turn the main circuit breaker to the "OFF" position before beginning this procedure. Failure to disconnect power to the machine may result in serious personal injury or death.

1. The X-axis drive motor is suspended from the X-axis bracket (60) at the left side of the machine. Unscrew the encoder and motor cable connectors from the motor.
2. Support the drive motor. Remove six screws securing the bracket cover (64) to the bracket. Lift the motor (with the bracket attached) away from the machine.
3. Remove three set screws from the pulley on the motor shaft. Insert three 10-32x0.875 socket head cap screws into the non-threaded holes in the pulley bushing. Tighten uniformly; the taper lock bushing inside the pulley will release. Slide the pulley off the motor shaft. (Note position of the pulley assembly on the motor shaft before removing.)
4. Remove four socket head cap screws (144) securing the motor mounting adapter (141) to the bracket.
5. Remove four flat head cap screws (142) securing the motor mounting adapter to the motor.
6. Reverse Steps 4 and 5 on replacement motor.

CAUTION

Ensure both pulleys provide proper belt alignment when reinstalling the taper lock bushing to the motor shaft.

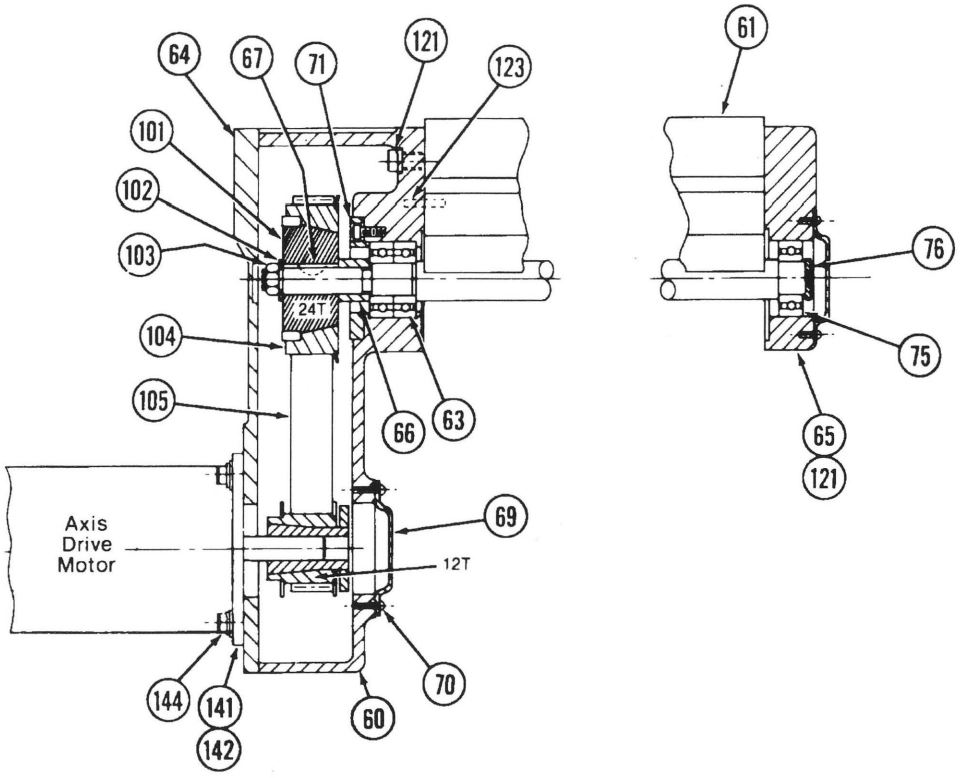



**Figure 9-1.** X-Axis Drive Assembly

7. Slide the pulley onto the shaft of the replacement motor. Remove the three socket head cap screws from the pulley. Insert three set screws in the threaded holes of the pulley. Tighten the screws uniformly until the taper lock is secured to the motor shaft.
8. Reverse Steps 1 and 2 to remount the motor. Position the motor taut against the timing belt before tightening the bracket cover screws.

### 9.1.2 X-Axis Drive Belt Replacement (Figure 9-1)

Turn the main circuit breaker to the "OFF" position before beginning this procedure. Failure to disconnect power to the machine may result in serious personal injury or death.

1. Remove the drive motor and bracket cover, see Section 9.1.1.
2. Remove the belt (105) from the drive pulley (104).
3. Install the new belt.
4. Replace the drive motor and bracket cover. Position the motor taut against the timing belt before tightening the bracket cover screws (64).

### 9.1.3 Y-Axis Drive Motor Removal (Figure 9-2)

Turn the main circuit breaker to the "OFF" position before beginning this procedure. Failure to disconnect power to the machine may result in serious personal injury or death.

1. The Y-axis drive motor is located at the right side of the knee. Unscrew the encoder and motor cable connectors from the motor.

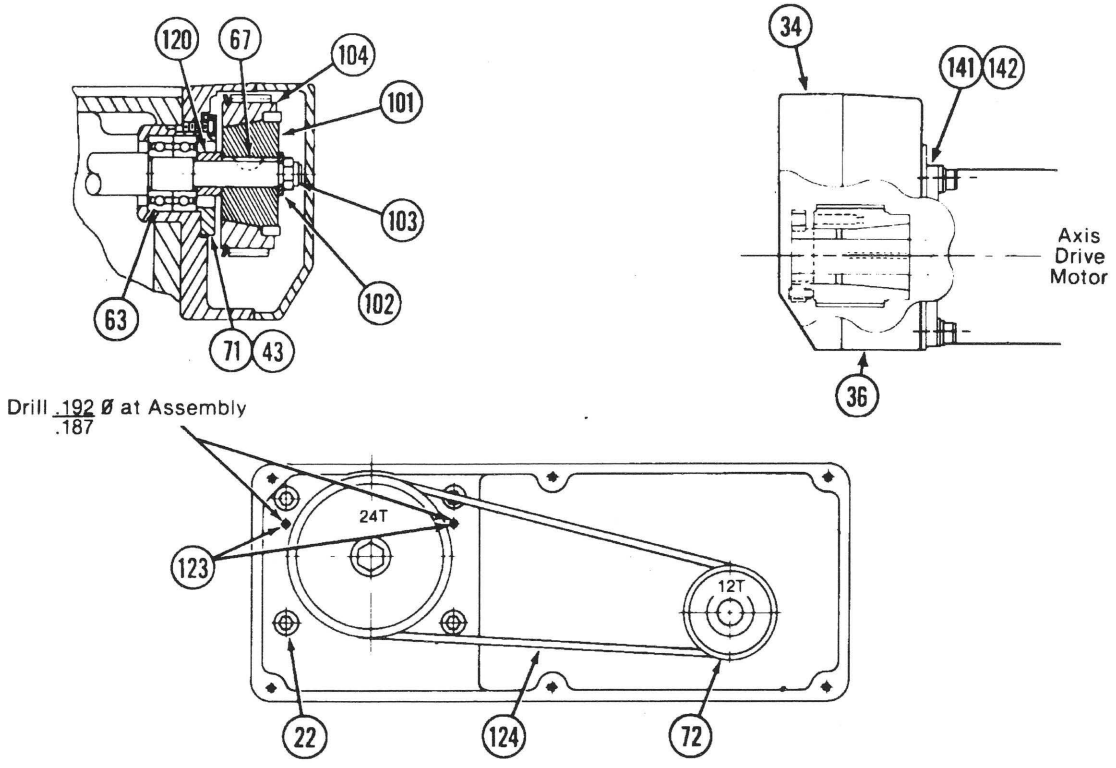



**Figure 9-2.** Y-Axis Drive Assembly

# 9. Base Assembly

2. Remove six screws from the Y-axis bracket cover (34). Remove the cover to expose the timing belt (124). Loosen the four socket head cap screws securing the motor mounting adapter (141) to the bracket (36). Slip the belt off the motor shaft pulley.
3. Remove three set screws from the pulley on the motor shaft (72). Insert three 10-32 x 0.875 inch socket head cap screws into the non-threaded holes in the pulley. Tighten uniformly; the taper lock bushing in the pulley will release. Slide the pulley off the motor shaft.
4. Support the motor. Remove four socket head capscrews securing the motor mounting adapter (141) to the bracket (36). Remove the motor (with the adapter and pulley attached) from the bracket.
5. Remove four flat head cap screws (142) securing the motor mounting adapter to the motor.
6. Attach the motor mounting adapter to the motor.

CAUTION

Ensure both pulleys provide proper belt alignment when reinstalling the taper lock to the motor shaft

7. Slide the pulley onto the shaft of the replacement motor. Remove the three socket head cap screws from the pulley. Insert three set screws in the threaded holes of the pulley. Tighten the screws uniformly until the taper lock is secured to the motor shaft.
8. After the motor is installed, the timing belt must be set with proper tension; see Section 9.1.5.

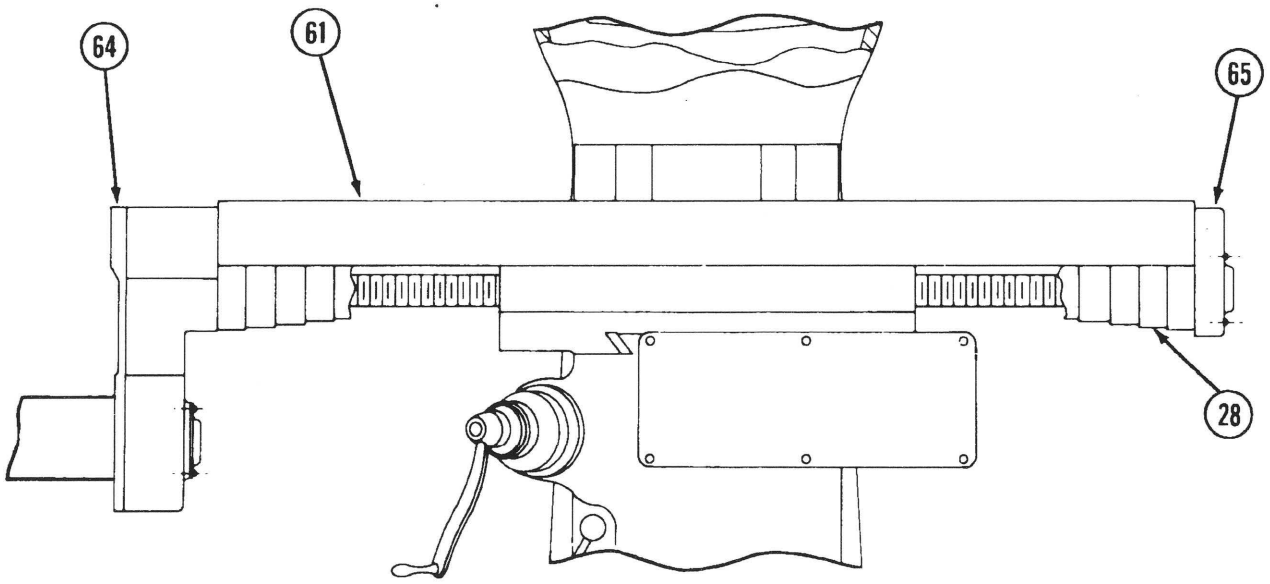



**Figure 9-3.** Base Assembly (Front View)

### 9.1.4 Y-Axis Drive Belt Replacement (Figure 9-2)

DANGER

Turn the main circuit breaker to the "OFF" position before beginning this procedure. Failure to disconnect power to the machine may result in serious personal injury or death.

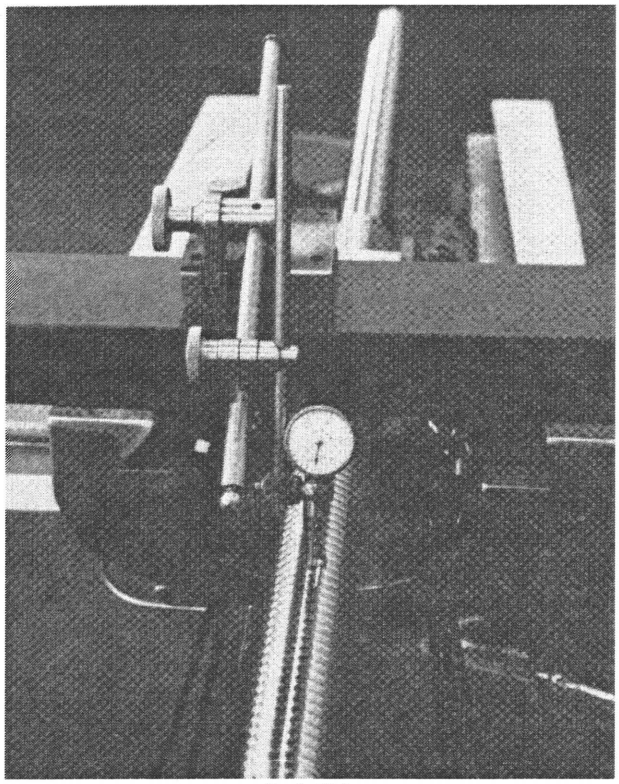
1. Remove six screws from the Y-axis bracket cover (34). Remove the cover to expose the timing belt (124).
2. Loosen four socket head cap screws securing the motor mounting adapter (141) to the bracket (36).
3. Slip the belt off the pulleys.
4. Install the new belt.
5. Set the belt tension; see Section 9.1.5. is set.

### 9.1.5 Y-Axis Drive Belt Adjustment (Figure 9-2)

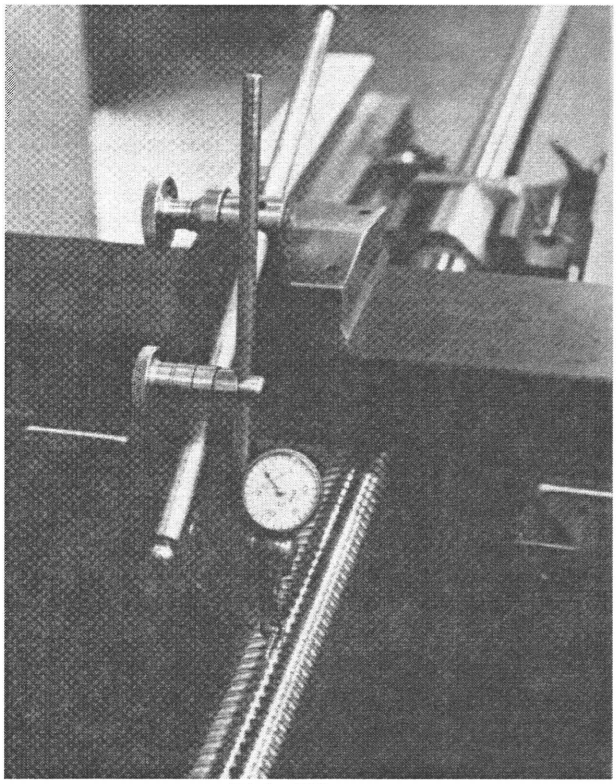
DANGER

Turn the main circuit breaker to the "OFF" position before beginning this procedure. Failure to disconnect power to the machine may result in serious personal injury or death.

1. Remove six screws from the Y-axis bracket cover (34). Remove the cover to expose the timing belt (124).
2. The belt should have a tension of 70-80 pounds, or it should deflect 3/8 inch (in the middle on one side) with 7-pound force applied.
3. Loosen, but do not remove, four socket head capscrews on the motor mounting adapter. Shifting the motor away from the knee increases tension; moving the motor toward the knee decreases tension.



Left Side



Right Side

**NOTE**

Ball screw must extend outward from nut bracket the same distance on the left as on the right.

**Figure 9-4.** X-Axis Vertical Ballscrew Inspection

4. Tighten the motor mounting adapter screws once proper tension is obtained.

### 9.2 X AND Y-AXIS BALLSCREWS

#### 9.2.1 X-Axis Ballscrew Removal (Figures 9-1 and 9-3)

1. Compress the ballscrew covers (28) on both the left and right sides of the table. Use Ty-wraps to secure the cover in the compressed position.

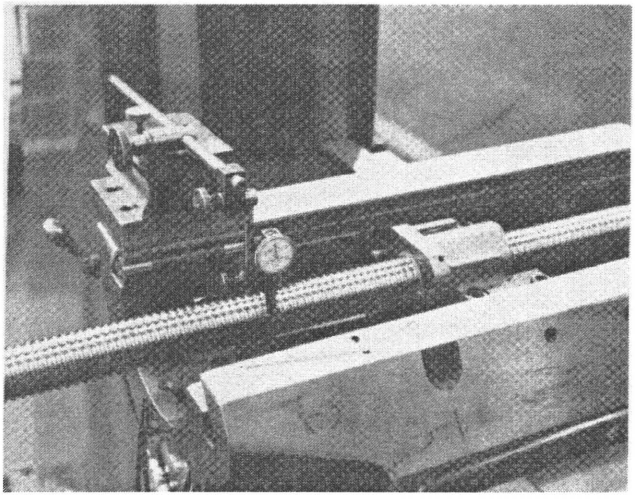
**WARNING**

Do not release cover from its compressed position! If the cover is released, it will spring open and may cause personal injury.

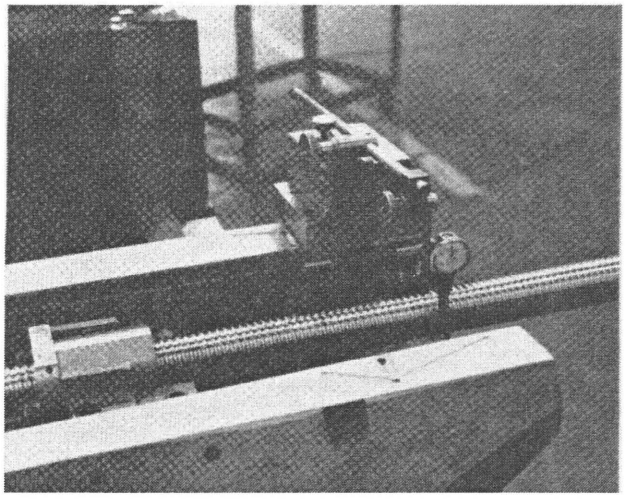
2. Remove the X-axis drive motor; see Section 9.1.1.
3. Remove the X-axis ballscrew drive belt (105) from the ballscrew drive pulley (104).
4. Remove four screws (70) securing the cover (69) to the bracket (65). Detach the bearing retainer plate (76) from the ballscrew.
5. Remove the bracket (65) from the right side of the table by removing the four socket head cap screws (121), exposing the end of the ballscrew. Remove the right side ballscrew cover.
6. Hold the pulley (104) and loosen and remove the locknut (103) and washer (102).
7. Remove the two set screws located in the taper lock bushing (101). Install the two set screws in the two remaining holes of the bushing. Tighten uniformly. Remove the pulley (104), bushing (101), key (67), and spacer (66) from the ballscrew.
8. Remove the four socket head cap screws (121) and slide the bracket (64)—together with bearings (63). retainer (71), and attaching screws (43) intact —away from the table. Dowel pins (123) should be removed from the end of the table. Remove the left side ballscrew cover.

**NOTE**

The two bearings (63) are angular contact bearings. They must be assembled in the same orientation as their disassembly to provide the proper direction of preload. Clean the diameter and line up the "V" marks on the outside diameters of the bearings:



Left Side



Right Side

**NOTE**

Ball screw must extend outward from nut bracket the same distance on the left as on the right.

**Figure 9-5.** X-Axis Horizontal Ballscrew Inspection

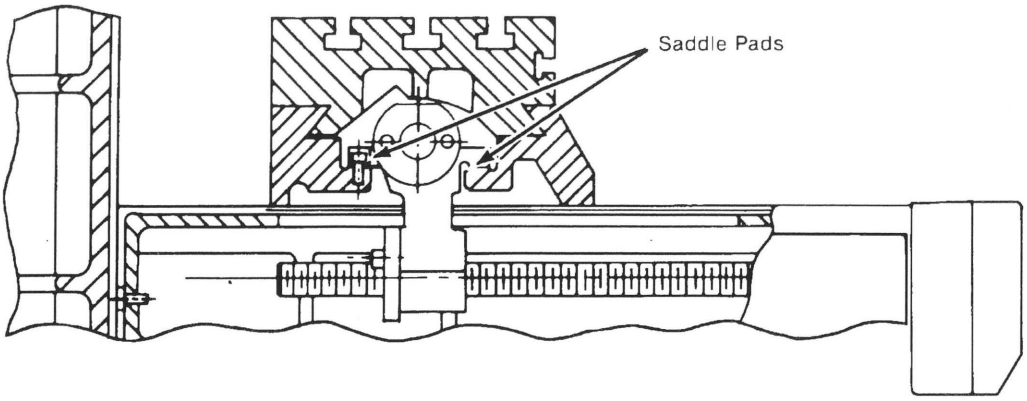



**Figure 9-6.** X-Axis Ballscrew Alignment

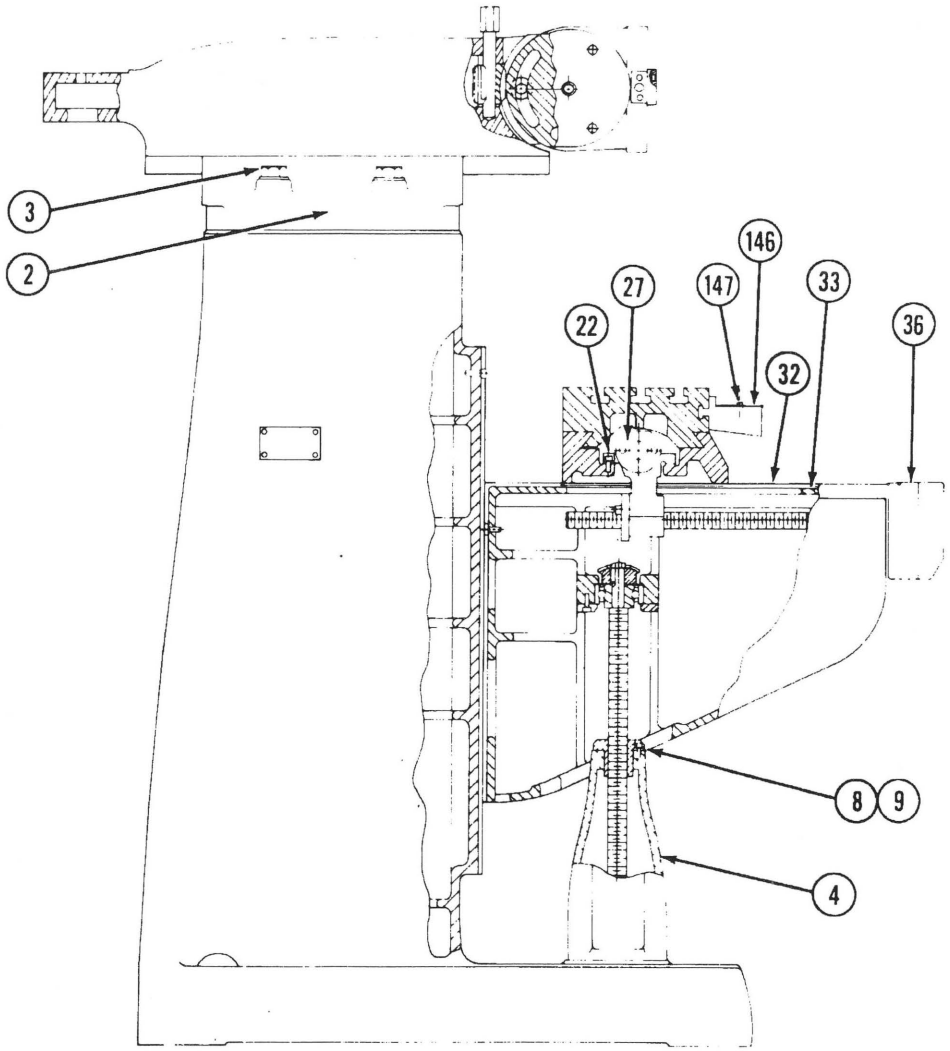



**Figure 9-7.** Base Assembly (Side View)

9. If the bearings (63) must be changed, the bearing retainer (71) and attaching screws (43) must be removed. Bearings can be pushed from the rear of the bracket .
10. Remove the table (61); see Section 9.4.1.
11. Remove the lubrication tube from the ballnut. Disengage the ballscrew from the ballnut bracket by removing socket head cap screws (27).

Reverse this procedure to reassemble the ballscrew. After reassembly, the vertical and horizontal alignment must be checked; see Sections 9.2.2 and 9.2.3.

### 9.2.2 X-Axis Vertical Ballscrew Inspection (Figure 9-4)

1. Place a granite block across the table ways. Place a dial indicator (regular surface gage) on the top of the block and on the left side of the ballscrew. Ensure the indicator is straight to the ballscrew.
2. Slide the indicator back and forth until the maximum reading is shown on the dial. Set the dial indicator to zero.
3. Reposition the granite block on the right side of the saddle and the indicator on the right side of the ballscrew.
4. Slide the indicator back and forth until the maximum reading is shown. If this reading exceeds 0.002, the pads in the saddle must be carefully scraped; see Section 9.2.4.

### 9.2.3 X-Axis Horizontal Ballscrew Inspection (Figure 9-5)

1. Place a Bridgeport special fixture ST 6474 on the left side of the rear table way. The edges of the way and the fixture should be flush. Position a dial indicator mounted on a magnetic surface on the fixture and on the left inner edge of the ballscrew.
2. Slide the fixture back and forth until the maximum reading on the indicator is shown. Set the indicator to zero. Ensure that the fixture is flush with the inner edge of the rear table way.
3. Move the special fixture to the right edge of the rear way. Position the fixture until the maximum reading on the indicator is shown. The difference from the zero reading on the left side to the reading first recorded above will be the amount of existing alignment error. If this reading exceeds 0.002 inch, loosen the four ballnut bracket screws, and pivot the bracket until properly aligned.

### 9.2.4 X-Axis Ballscrew Alignment (Figure 9-6)

If parallelism of the X-axis ballscrew is not within 0.002 inch tolerance, scraping must be done to correct alignment.

**CAUTION**

Exercise extreme care in scraping the saddle pads. Careless scraping could result in serious machine damage.

Correct alignment by carefully scraping the saddle pads until the ballscrew is in exact parallelism with the saddle way. Both pads (front and back) must be scraped evenly. Ensure the front and back saddle pads are parallel within 0.001 inch to each other.

### 9.2.5 Y-Axis Ballscrew Removal (Figures 9-2 and 9-7)

1. Move the saddle out to the maximum distance from the column.
2. Remove the X-axis ballscrew; see Section 9.2.1.
3. Remove the Y-axis drive belt (124); see Section 9.1.4, Steps 1, 2, and 3.
4. Remove three set screws from the pulley on the motor shaft (72). Insert three 10-32 x 0.875 inch socket head cap screws into the non-threaded holes in the pulley. Tighten uniformly; the taper lock bushing in the pulley will release. Slide the pulley off the shaft.
5. Support the Y-axis motor. Remove four screws and the drive motor from the bracket (36).
6. Remove the ballscrew bearing locknut (103) and washer (102) from the ballscrew.

7. Remove the two set screws from the taper lock bushing (101). Install two set screws in the two remaining holes of bushing. Tighten uniformly. Slide the bushing (101) and pulley (104) off of the screw end. Remove key (67) and spacer (120) from the ballscrew.

**NOTE**

The two bearings (63) are angular contact bearings. They must be assembled in the same orientation as their disassembly to provide the proper direction of preload. Clean the diameters and line up the "X" marks on the outside diameter of the bearings.

8. Remove the bearing retainer plate (71) and attaching screws (43). Pull the saddle forward to push the bearings out of the bracket. Remove the bearings from the ballscrew.
9. Support the bracket (36) and remove the attaching screws (22) to remove the bracket.
10. Remove the side cover plate (136), Figure 9-11, located on the right side of the knee.

**CAUTION**

Do not bend the brass lubrication line when removing it from the ballnut. If the line is bent, a new line and fitting must be purchased from your Bridgeport representative.

11. Disconnect the lube line to the Y-axis ballnut at the saddle.
12. Remove the socket head cap screws (27) which attach the ballnut bracket to the ballscrew.
13. Slide chip guards (32) and (33) out from under the saddle.
14. With the saddle in the full forward position, gently lift the ballscrew from the knee opening.

**To replace the ballscrew:**

1. Wind the ballnut to the approximate center of the ballscrew.
2. With the saddle in the full forward position, place the Y-axis ballscrew assembly in the knee.
3. Position the saddle in its center of travel (over the ballnut).
4. Replace the chip guards, sliding them forward to expose an opening in the knee for alignment inspection.
5. Mount the ballnut bracket to the saddle; leave the four screws (22) loose enough to allow adjustment, but tight enough to accurately align the ballscrew.
6. Install screws (27) connecting the ballnut bracket and the ballscrew assembly. Leave screws loose enough to allow adjustment, but tight enough to align the ballscrew.
7. Assemble bearings (63) into bracket (36), locking bearings in position with the bearing retainer (71) and attaching screws (43).
8. Slide the bracket with bearings onto the ballscrew. Install four screws (22), but leave screws loose enough to allow adjustment.

**NOTE**

Vertical and horizontal alignment of the ballscrew must be checked before proceeding with reassembly, see Section 9.2.6.

9. Drill two 3/16 roll pin holes, Figure 9-2. Insert 3/16 roll pins (123).
10. Tighten securely the screws (27) connecting the ballnut bracket and the ballscrew assembly.
11. Install the ballnut lube line from the lube manifold (located in the saddle cavity), through the saddle, and into the ballnut flange hole.

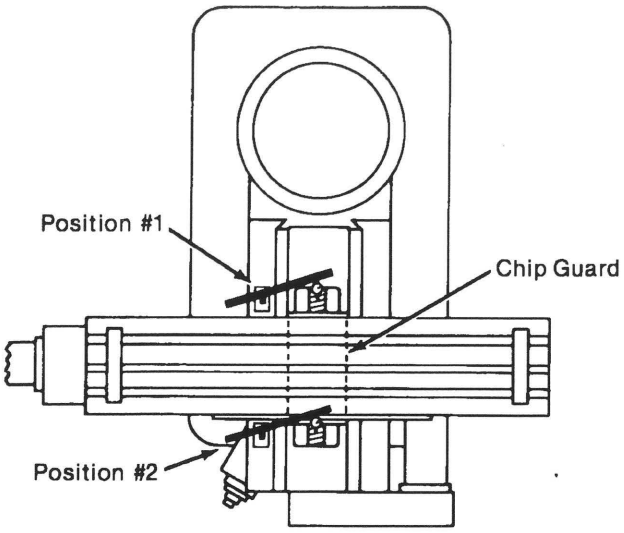



**Figure 9-8.** Y-Axis Ballscrew Inspection

CAUTION

When reassembling the drive pulley assembly onto the ballscrew, tighten the locknut alternately with the pulley set screws. Tighten only to a snug fit. If the locknut and set screws are too tight, the taper lock bushing may split apart.

12. Replace the drive pulley (104), bushing (101), key (67), and spacer (120) on the ballscrew. Install washer (102) and locknut (103) on the ballscrew and tighten.
13. Attach the knee side cover plate.
14. Mount the Y-axis motor and reinstall the Y-axis drive belt. Set proper tension on the belt; see Section 9.1.5.
15. Reinstall the X-axis ballscrew by reversing the procedure in Section 9.2.1.
16. Set the saddle-to-knee and saddle-to-table gibs; see Sections 9.7.1 and 9.7.2.
17. Set the X and Y-axis trip dogs; see Sections 9.3.1 and 9.3.3.

### 9.2.6 Y-Axis Ballscrew Inspection and Alignment (Figure 9-8)

CAUTION

The Y-axis ballscrew does not have protective stops to prevent the ballnut from winding off the end of the screw. If the ballnut and ballscrew disengage, a new ballscrew assembly must be purchased.

1. Position the saddle in its center of travel. Rotate the ballscrew in a counterclockwise direction until it extends approximately two inches beyond the front of the saddle. This should provide enough clearance to allow the chip guards to be moved toward the front of the knee, exposing the ballscrew near the column.
2. Place a surface gauge on the knee way near the column. Mount a dial indicator from the surface gage extended to the top of the ballscrew. Ensure the indicator is straight to the ballscrew.
3. Slide the surface gage back and forth until a maximum reading is shown on the indicator. Set the indicator to zero.
4. Move the chip guards toward the rear of the machine. Reposition the surface gauge on the knee way toward the front of the machine. Slide the surface gage back and forth until a maximum reading is shown on the indicator. If the reading exceeds 0.002 inch from the original zero setting at the initial reading, insert shims under the ballnut bracket to bring the vertical alignment within the required tolerance of 0.002 inch.

**NOTE**

The saddle-to-knee gib must be temporarily set before measurements of parallelism can continue. See Section 9.7.2.

5. Place a 0.750 inch diameter gauge pin against the knee dovetail (near the front of the machine). Position a surface gauge against the gage pin and extend a dial indicator to the side

of the ballscrew. Move the surface gage until a maximum reading is shown on the indicator. Set the indicator to zero. Move the chip guards toward the front of the machine to repeat the process at the rear of the screw. The difference in readings for parallelism of the ballscrew in the horizontal plane should not exceed 0.0002 inch. If so, clearance holes in the ballnut bracket for the mounting screws (22), Figure 10-7, provide adjustment. Adjust the ballscrew until the tolerances are brought within 0.002 inch.

6. Tighten the four.mounting screws (22). Check for parallelism of the ballscrew in both the vertical and horizontal planes. Correct any misalignment.

## 9.3 LIMIT AND HOME SWITCH ADJUSTMENTS AND REPLACEMENT

### 9.3.1 X-Axis Home and Overtravel Limit Switch Setting (Figure 9-9)

Conceptually, the limit switch trip dog should be set to trip when the axis travel is 0.100 inches from the mechanical limit. In the case of the V2XT X-axis, the home trip dog should be set so that the software limit of travel is symmetrical with the saddle. The home switch should be set so that 0.600 inch of the saddle way shows on the right side when the X-axis is at the home position.
To set the X axis home switch.

1. Move the X axis table to the left until 0.600 inches of the saddle way is showing on the right edge of saddle.
2. Remove the X axis motor bracket and motor and lay on the floor.

Lethal voltages are present in the Power Distribution Enclosure, even when the main disconnect is off. Use extreme caution whenever working in the enclosure.
Failure to do so may result in serious personal injury or death.

3. Rotate the lead screw in the clockwise direction one and one quarter turn. This is the position that the trip dog should activate the X-axis limit switch.
4. Rotate the lead screw in the counterclockwise direction one and one quarter turn.

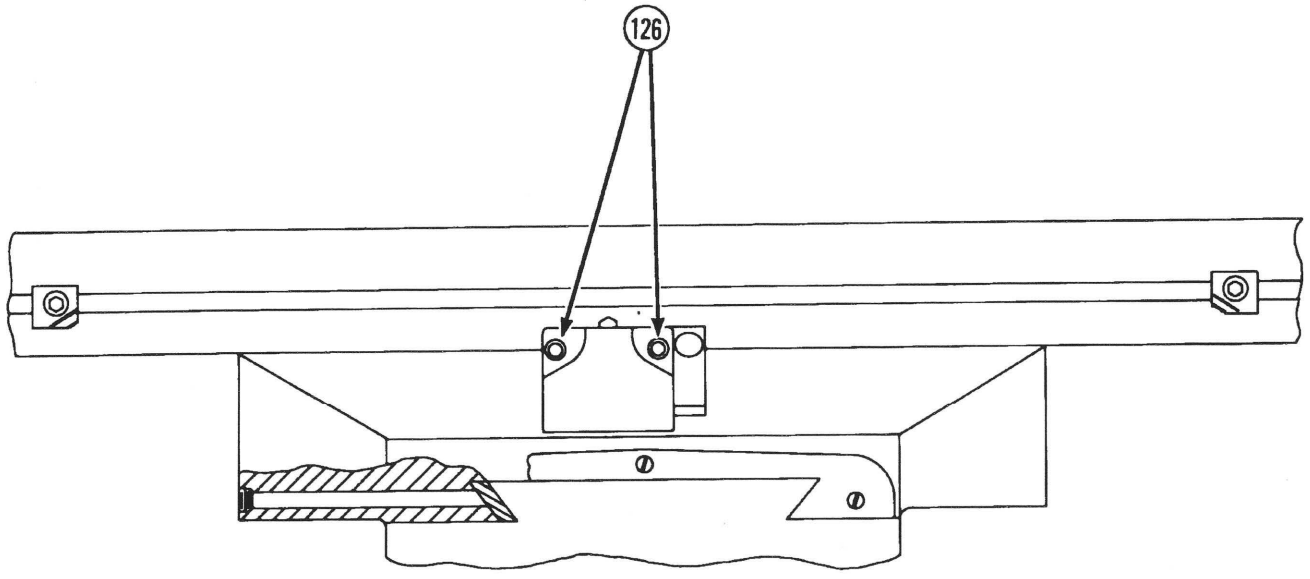



**Figure 9-9.** X-Axis Limit Switch

5. At the control console, press button number 7 to enable the axis motors.
6. Press button number 8 twice to home the machine.
7. When the X-axis motor starts to rotate, press down on the home switch actuator until the motor homes.
8. Go to the set-up page of the control.
9. Press the DOS button, 9. The control will come back and ask "Go to DOS". Type Y.
10. The control will display a DOS prompt. Type in TUNER and enter.
11. Press the Set Jog button, 8. Enter X in the lighted box and enter twice. The control is now set to jog.
12. Press the Enter Offsets button, F10. Enter 1 to select the user mode.
13. Using the Enter key, page to the X-axis entry and enter 0. Page down until the block clears.
14. The axis position on the upper left side of the display will read 0.0 and the control is in jog.
15. Turn the axis jog knob until the display reads 2500. The motor and the X-axis lead screw are synchronized to the same revolution.
16. Carefully install the X-axis motor.
17. Lock up the trip dog screws.
18. Send the tables to home.
19. Go to Enter Offsets and set the X-axis readout to 0.0.
20. Set the display to METRIC by pressing the F6 button.
21. Set the machine to jog.
22. Jog the axis minus until the home switch display reads OFF. Slowly rotate the Jog Knob positive until the switch readout changes to ON.
23. The axis position must read between 2800 and 2900. If it does not, jog the tables to position 2850.
24. Repeat steps 16 to 22 until the machine will pass step 23. Failure to pass this test can cause inconsistent home positioning by one motor revolution.

### 9.3.2 Synchronizing the X-Axis Motor

When replacing the X-axis motor, the motor can be synchronized with the axis as follows:

1. Mount the new motor on the X-axis mounting bracket.
2. Reset the control and home the machine. Refer to 10.3.1 for details.
3. Offset the motor by using the X-axis displacement register to 2500. Refer to 9.3.1.
4. Turn the lead screw until the X-axis trip dog just activates the home switch when traveling in the home direction. Refer to 9.3.1 to display the switch status.
5. Carefully mount the new motor.
6. Do steps 23 through 28 of section 9.3.1.

Lethal voltages are present in the Power Distribution Enclosure, even when the main disconnect is off. Use extreme caution whenever working in the enclosure.Failure to do so may result in serious personal injury or death.

### 9.3.3 Y-Axis Home Switch Setting.

The Y-axis travel from mechanical limit to mechanical limit is about 12.30 inches setting the Y-axis limit requires care.

To set the Y-axis home switch, perform the following steps:

1. Loosen the Y-axis taper lock pulley on the Y-axis motor. The lead screw pulley and belt should turn freely.
2. With the control in the emergency stop mode, rotate the Y-axis pulley counter-clockwise until it reaches the mechanical limits. Then rotate the pulley clockwise two complete revolutions. The axis is now positioned to the correct revolution for operating the home switch.

CAUTION

Ensure that port A is jumpered to port B.

3. Hold down the CTRL key and press letter button O. The display should read "line feed off". Press button V to read the SAF status registers.
4. Adjust the home switch trip dog from the column toward the front of the knee until register D4 just changes state. Lock-up the adjustment.
5. Turn the Y-axis pulley until the trip dogs clear the Y-axis limit switch.
6. Return the control to the set-up page by pressing the ESC and then the F2 button.
7. Send the control to home. When the Y-axis motor starts turning, press down and hold the Y-axis home switch until the X-axis completes homing.
8. At the control, press button 1 and 3 to get to the jog page. Press button 4 and 6 to get to Y-axis jog knob 0.1 inch/rev.
9. Press number button 0 twice to go to the set-up page. Then press button 2 to go to system monitor.
10. Press letter button Y to display the Y-axis status register. The last column to the right of the display is the axis absolute position register from home. It should now read zero.
11. With the jog knob, set the register to read 2850. The motor is now set at the position were it would be activating the home switch.
12. Press the ESC button followed by the V button. The SAF registers are now displayed.
13. Press the Y-axis home switch and note the bit change in column D4. Now using the Y-axis lead screw, move the saddle toward the front of the knee until the limit switch trip dog activates the home switch and D4 changes. Back the trip

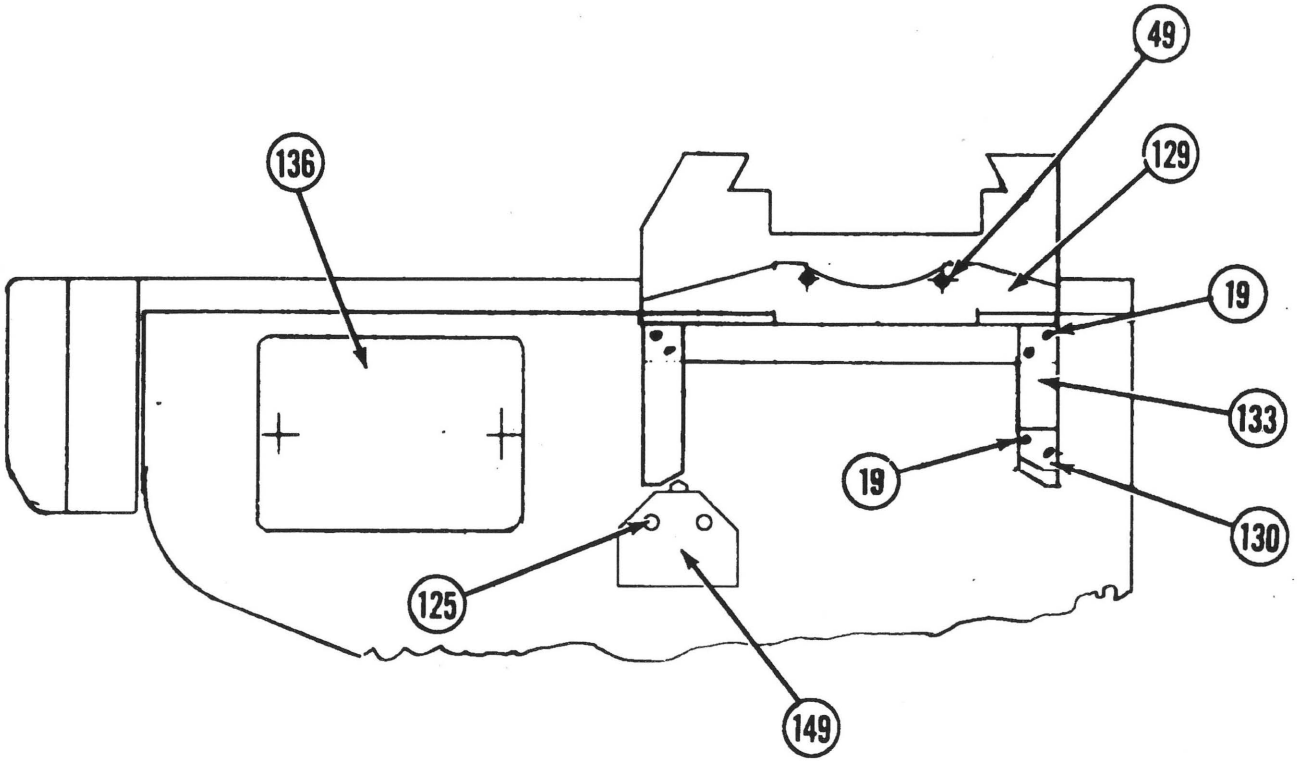



**Figure 9-10.** Y-Axis Limit Switch

off of the switch until D4 changes back to original state. Slowly bring the saddle forward until the D4 changes, stop. Tighten the Y-axis drive pulley onto the motor shaft.

14. To check the accuracy of the switch setting, slowly move the saddle back toward the column with the jog knob until column D4 on the display changes state. Reverse the axis direction and slowly bring the axis forward until D4 changes back to the closed state.
15. Press the ESC button and the Y button the last column should read between 2800 and 2900. If not, move the axis until the read-out is set to 2850. Press the ESC button and the V button.
16. Adjust the home switch trip dog from back to front until D4 changes state to indicate that the switch closed. Tighten all bolts.
17. Repeat steps 15,16 and 17 until the Y-axis displacement register reads 2800 to 2900.

### 9.3.4 Setting the Y-Axis Limit Switches

1. Home the machine and turn off power at the disconnect. Remove connector K2 from the SAF card. Close the cabinet and turn on the control.
2. Press button number 7 to enable the axis. Clear all messages and warning.
3. Press button number 1 and button number 3 to go to the jog page. Select Y-axis jog knob at 0.1 inch per rev.
4. Press the number button 0 twice to go to the system set-up page.
5. Press button number 2 to go to system terminal.

**NOTE**

Ensure that port A is jumpered to port B.

6. Hold the CTRL button and press the letter button O. Display should read "line feed off".
7. Press the V button. The SAFL registers should be displayed.
8. With the Jog knob, jog the axis post the home position until register D4 just changes state.
9. Press the ESC button and then the Y button. The Y-axis register is displayed. The last column is the axis displacement register. The number should be -300. If it is not, set the register to -300.
10. Press the ESC button followed by the V button.
11. Remove the cover plate from the bottom of the Y-axis limit switch. If switch is activated, back off on the switch until D4 changes state and then slowly tighten the switch until D4 changes back.
12. Press the ESC button followed by the Y button.
13. Jog the axis with the Jog knob to the other end of the table and set the displacement register 120300.
14. Press ESC button followed by the V button.
15. Adjust the limit switch trip dog until D4 changes state.
16. Check the travel limits. If they are correct, turn off the machine and install K2 on the SAFL card. Replace the cover on the limit switch.

### 9.3.5 Synchronizing the Y-Axis Motor

If the Y-axis trip dog bracket has not moved, perform the following instructions. If it has moved, start at 9.3.4.

1. Using the Y-axis ball screw pulley, move the saddle to the middle of travel.
2. Install the new motor, belt and drive pulley. Do not tighten the pulley onto the motor shaft.
3. Turn on the control. After the control boots up, hit button number 7 and then hit button 8 twice to home the machine.
4. When the Y-axis motor starts to rotate, press down and hold the Y-axis home switch. After the X-axis is homed, release the home switch.
5. On the keyboard, hit button 1 and then button 3 to go to the jog page. Hit button 4 and then button 6 to go to jog knob Y-axis.
6. Hit number button 0 twice to go to the system setup page.
7. Hit button 2 to go to the system terminal.

**NOTE**

Ensure Port A is jumpered to port B.

8. Hold down the CTRL button and hit the letter button 0. The display should read "line feed off".
9. Hit the Y button. The Y-axis position registers should be displayed. The last register on the right is the Y absolute register.
10. Using the axis jog knob, set the axis displacement register to read 2850. The motor is now set to the point that it would normally activate the home switch.
11. On the keyboard, hit ESC button and then the V button. The SAF card register is now displayed. The Y-axis home switch closure is displayed in column D4. Hit the home switch and not the bit change.
12. Using the Y-axis driven pulley, crank the saddle toward the front of the knee. Go very slowly as the home switch trip dog approaches the home switch. As soon as the bit in register D4 changes, stop. Lock up the pulley on the motor shaft.
13. To check the accuracy of the setting, slowly crank the axis off of the home switch with the Job knob.
14. Moving no faster than a click at a time, move the axis forward over the home switch. As soon as the bit in D4 changes, stop.
15. Press the ESC button followed by the Y button. The axis displacement register should read between 2800 and 2900.
16. If it is between the limits, the motor is aligned with home switch. If it is not between the limits, loosen the pulley on the motor shaft and repeat steps 10 through 15.

## 9.4 TABLE AND SADDLE REMOVAL

### 9.4.1 Table Removal (Figure 9-1) (Refer to Section 9.2.1)

1. Move the table to the middle of the X-axis.
2. Remove the table gib adjusting screw and remove the gib, Figure 9-12.
3. Support the table with an overhead hoist and slide it to the right until it clears the spindle. With hoist assistance, carefully lift the table. Slide the table off the saddle ways until it clears the saddle. Take care to avoid bumping the ballscrew assembly.

**WARNING**

The table weighs 300 pounds. Use appropriate care to prevent equipment damage and possible personal injury.

### 9.4.2 Saddle Removal

1. Move the saddle to the full out position (maximum distance from the column).
2. Remove the table from the machine. See Section 9.4.1.
3. Remove the X-axis ballscrew assembly. See Section 9.2.1 .
4. Remove the Y-axis drive belt. See Section 9.1.4, Steps 1 and 2.
5. Remove the Y-axis ballscrew assembly. See Section 9.2.5.
6. Disconnect the lubrication line at the left underside of the saddle.
7. Remove the front wiper cover and slide the rear wiper cover toward the column head.
8. Remove the X-axis limit switch. Refer to Section 9.3.2.
9. Remove the saddle to knee gib screw and gib. (Figure 9-12)

**WARNING**

The saddle weighs 100 pounds. Use appropriate care to prevent equipment damage and possible personal injury.

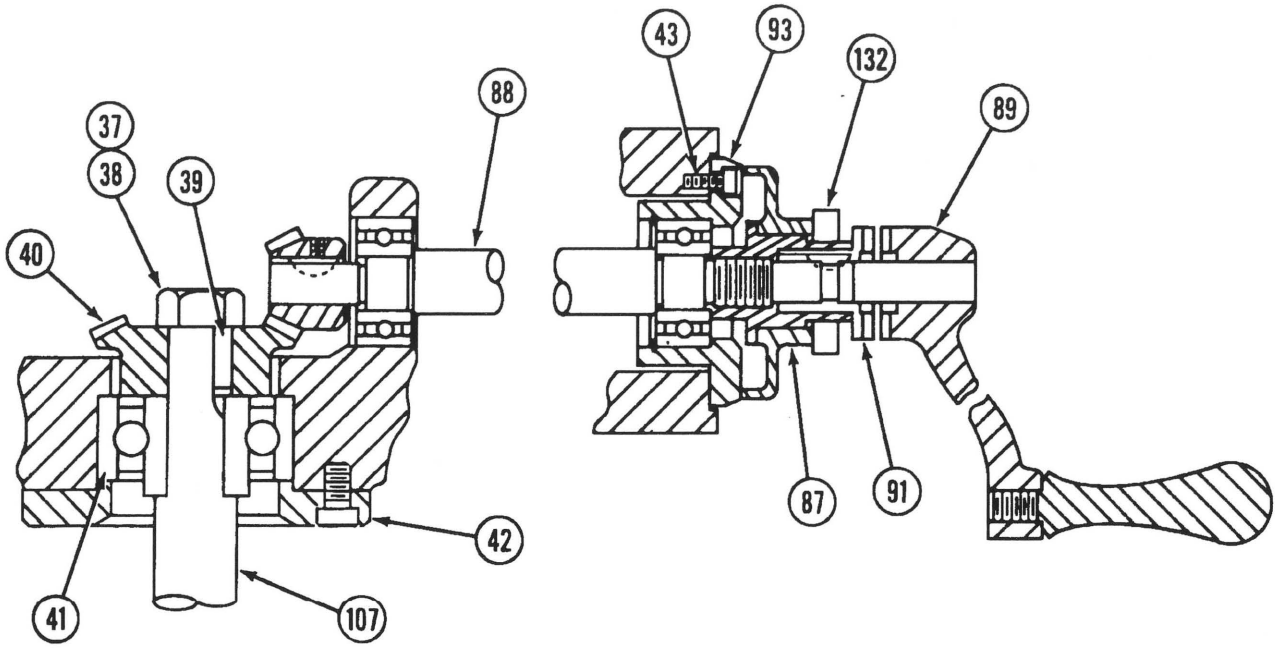



**Figure 9-11.** Manual Knee Drive

10. Support the saddle with an overhead hoist, and slide it to the front until it clears the knee.

## 9.5 MANUALLY OPERATED KNEE DRIVE (Figure 9-11)

### 9.5.1 Dial Replacement

1. Slide the knee crank handle (89) off its shaft (88).
2. Pry the clutch (91) out from the knurled locknut (132) and remove it from the shaft.
3. Unscrew and remove the locknut (132).
4. Slide the dial (87) off the end of the shaft.
5. The fitting of a new dial requires the cutting of the dial outer face for a 0.005 inch gap.

### 9.5.2 Crank Shaft Removal

1. Remove the elevating dial. See Section 9.5.1.
2. Remove three screws (43) to release the bearing retainer (93), allowing the knee elevating crank shaft and bearing to be withdrawn from the knee.

### 9.5.3 Knee Removal

**WARNING**

To avoid personal injury and damage to the machine, the knee must be either blocked up from underneath or supported by a hoist throughout this operation.

1. Remove the saddle. See Section 9.4.2.
2. Remove the knee elevating crank. See Section 9.5.2.
3. Remove the Y-axis limit switch. See Section 9.3.4.
4. Remove the lube lines from the left side of the knee.
5. Reach in through the top of the knee and remove the hex head jam nut (37), washer (38), and gear (40) from top of the knee elevating screw (107).

**NOTE**

The head will have to be removed. The procedure is described in Section 9.2.2. After the head has been removed, support

the knee with an overhead hoist. Complete the procedure starting with Step 6.

6. Loosen the four screws (3) securing the turret (2), Figure 10-7, to the top of the column. Do not remove these screws. Turn the ram and head to clear the area above the knee and attach a suitable sling and hoist to support and raise the knee.
7. Remove the way wiper felt and wiper holders to expose the knee-to-column gib, Figure 9-12.

CAUTION

Use care to avoid damage to the upper end of the knee elevating screw which remains on the column pad.

8. Remove the gib by removing the adjusting screw.
9. Lift the knee upward off the knee-column ways.

### 9.5.4 Knee Elevating Screw Replacement (Figure 9-11)

1. Support the knee with a chain hoist or floor jack.
2. Remove the knee elevating crank shaft. See Section 9.5.2.
3. Remove the cover plate located on the right side of the knee.
4. Through this side opening, remove the hex head jam nut (37), washer (38), and gear (40) from the top of the elevating screw (107).

**NOTE**

In lifting the knee, the knee elevating screw will slide out of the bearing assembly. The bearing retainer (42) and bearing (41) should remain intact in the knee.

5. Lift the knee up slowly to its maximum travel.
6. Lock the knee in place. Block or support the knee with a hoist.
7. Remove the elevating screw key (39) from the slot in the top of the screw.
8. Remove two screws (9), Figure 10-7, securing the knee elevating leadscrew nut (8) to the pedestal (4).
9. Lift the elevating screw out of the pedestal, pulling it upward and forward.

## 9.6 LUBRICATION (Refer to Dwg. 1241-0080 in the Parts Manual)

### 9.6.1 X, Y, and Z-Axes

The table, saddle, and head quill are lubricated by an automatic system whenever the spindle motor is running.

The oil reservoir and pump are located on the upper left side of the machine column.

A float switch in the oil reservoir prevents restart of the spindle if the oil level is too low.

**NOTE**

The float switch will not stop the spindle while it is running, but will protect it against restarting without sufficient lubrication.

Oil distributors for the table and saddle are located inside the saddle and can be exposed by removing the table. For instructions on table removal, see Section 9.4.1. Oil distributors for the head quill are located on the left side of the column.

**NOTE**

Use only Waylube 1180 or equivalent to ensure maximum effectiveness of the lubrication system.

All other moving parts, such as bearings, gears, etc., are pre-packed with lifetime grease at the factory and should not require further servicing for their full service life.

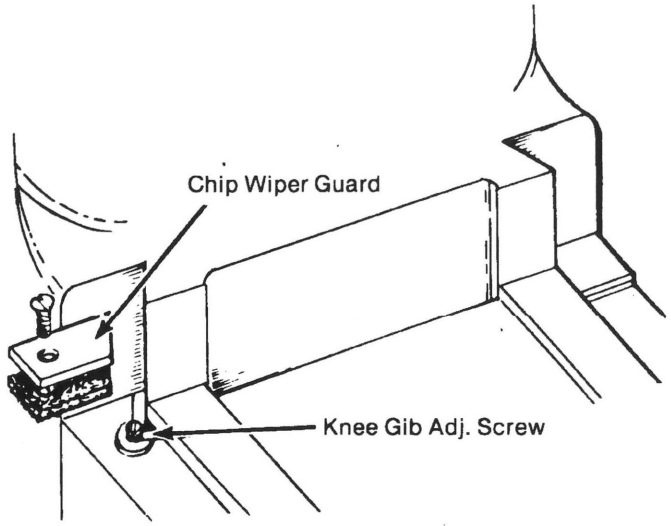
## 9.7 ADJUSTMENT OF TABLE AND SADDLE GIBS

All gibs are given an initial setting at the factory. After the machine is cycled for approximately 50 hours, the gibs are given a final setting. Therefore,

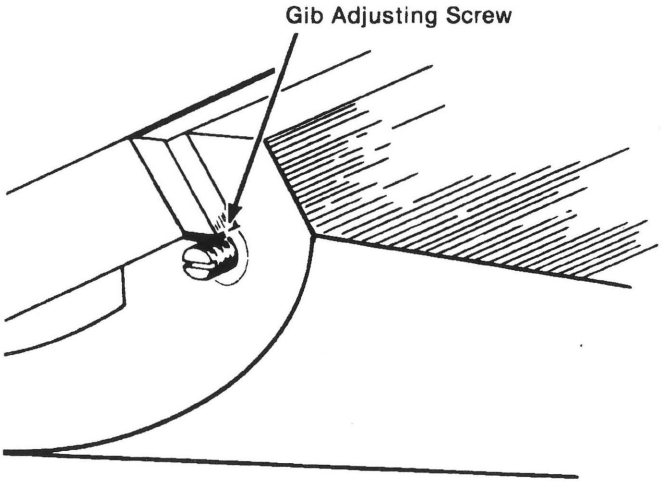
gibs should not require readjusting if proper maintenance of the automatic lube system is provided. If adjustment does become necessary, proceed as follows.

### 9.7.1 Saddle to Table Gib Setting (Figure 9-12)

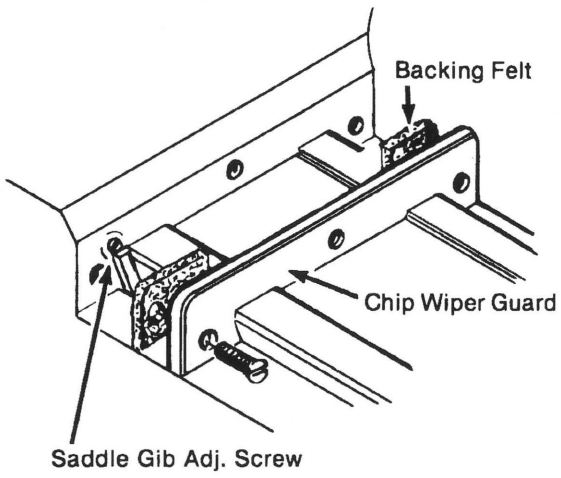
Use a magnetic-based indicator with the capability of reading minimum measurement of 0.0001 inch. Refer to Figure 9-13 for indicator setup positions.




Knee to Column

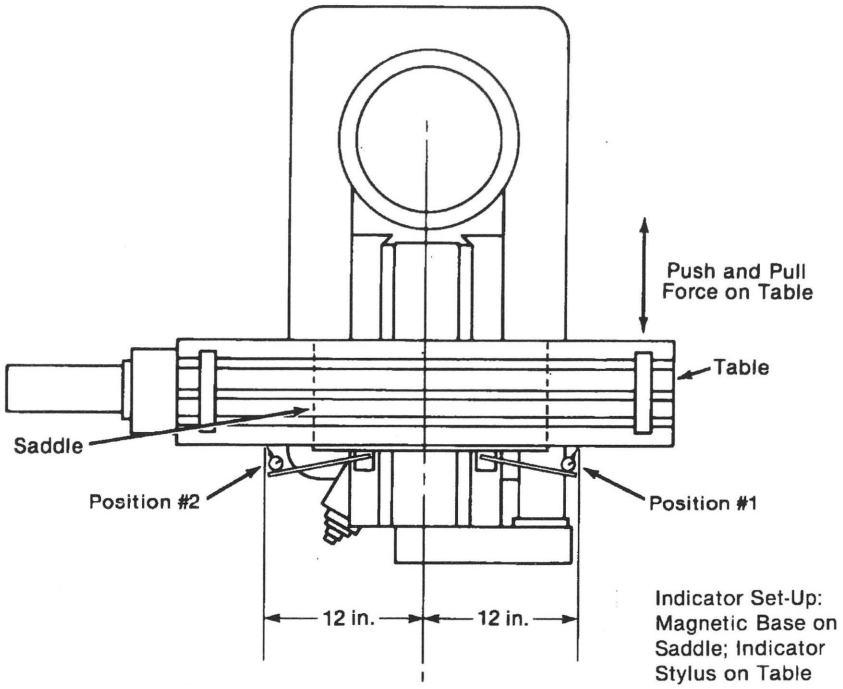



Saddle to Table

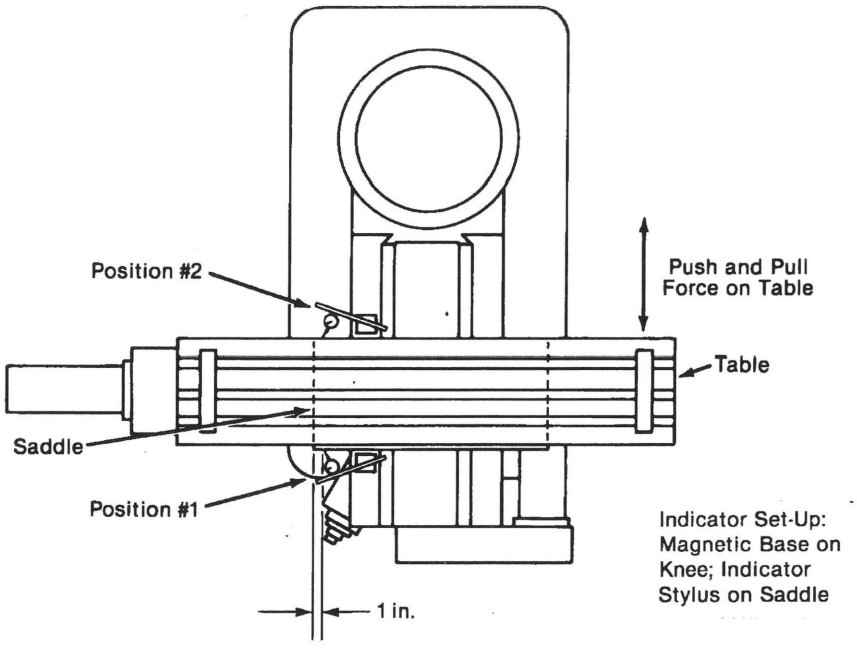



Saddle to Knee

**Figure 9-12.** Gib Locations




Saddle to Table Gib Setting




Saddle to Knee Gib Setting

**Figure 9-13.** Gib Adjustments

1. Set up the indicator in Position No.1.
2. Push the end of the table in the direction indicated in Figure 9-13. Release the table. Pull the end of the table and release. Note the total indicator reading, less springback.
3. Slightly turn the gib adjusting screw (Figure 9-12) and check the indicator reading. Continue turning the screw (l/4 turn at a time) until a maximum indicator reading of 0.0005 inch is obtained, less spring-back.
4. After the gib is set, move the indicator to Position No. 2.
5. Push and pull on the end of the table, and note the total indicator reading (less springback).
6. The total indicator reading in Position No. 1 (after the gib is set) should equal the total indicator reading in Position No. 2 within + 0.0002 inch. If not, remove and scrape the gib. Repeat the setting procedure to check alignment.

### 910.7.2 Saddle to Knee Gib Setting (Figure 9-12)

1. Move the saddle to the middle of the knee for both front and back checks.
2. Place the magnetic base on the knee way in front of the saddle. Place a 0.0001 indicator with the stylus on the saddle as shown in Position No. 1, Figure 9-13.
3. Push the end of the table in the direction indicated in Figure 9-13. Release the table. Zero the indicator. Pull the end of the table and release. Note the total indicator reading, less springback.
4. Slightly turn the gib adjusting screw (Figure 9-12) and check the indicator reading. Continue turning the screw (1/4 turn at a time) until a maximum indicator reading of 0.0005 inch is obtained, less spring-back.
5. Place the magnetic base on the knee way to the rear of the saddle. Position a 0.0001 indicator with the stylus on the saddle as shown in Position No. 2, Figure 9-13.
6. Push the end of the table in the direction indicated in Figure 9-13 (Setup No. 2). Release the table. Zero the indicator. Pull the end of the table and release. Note the indicator reading, less springback.
7. The total indicator reading in Setup No. 1 (after the gib is set) should equal the total indicator reading in Setup No. 2 within +0.0002 inch. If not, remove and scrape the gib. Repeat the setting procedure to check alignment.

### 9.7.3 Knee to Column Gib Setting (Figure 9-12)

1. Remove the way wiper cover (1106-0093) and wiper (1106-2405) to expose the knee to column gib.
2. Smooth motion of the knee (using the crank handle) indicates proper gib setting. Turn the gib adjusting screw (1/4 turn at a time) until smooth motion occurs.

## 9.8 BACKLASH COMPENSATION ADJUSTMENT

### 9.8.1 Introduction to Backlash

Backlash compensation is combined with the command as a preset digital value. The backlash value is added to the command position at the beginning of each negative move and subtracted from command position at the beginning of each positive move.

The backlash value for each compensated axis is stored in the memory of the microprocessor subsystem. These values are determined by accurate measurement of the machine tool and then are entered into the system. The control system can permanently store these values so they are not lost after an Emergency Stop, Reset, or Power Down.The backlash compensation values for the X and Y-axes may be entered into the control system memory at any time using the "Backlash Compensation Mode" feature of the V2XT system.

### 9.8.2 Backlash Adjustment Using Software Compensation

This procedure adjusts the logic to compensate for mechanical backlash in the axes.
Equipment needed:

—Actual table position measurement device.

—Dial indicator with 0.0001 inch or smaller resolution.

**NOTE**

Ensure the lost motion in the X, Y-axes is within specifications and the gibs have been properly set.

To adjust the X-Axis:

1. Enable drives and home axis.

2. From Basic Menus, select (9) JOG.

3. Jog axis to the center of the table.

4. Mount the indicator on the table to the right of spindle (parallel to the X axis).

5. Jog axis so the indicator makes contact with the spindle.

6. Set indicator to 0.

7. Jog axis past 0 approximately .001, then back to 0 to insure backlash is taken out for this test.

8. Set the X to 0 by selecting (F6) SET X.

**NOTE:**

Make sure indicator still reads 0. If not, adjust by turning the dial on the indicator.

9. Select (+) MOVE X_Y_Z_ and enter 1.0 for X. Leave the Y and Z blank.

10. At the prompt, press (+) to move the axis.

11. Select (+) MOVE X_Y_Z_ and enter 0 for X. Make this move back to 0.

12. The lost motion should now be seen on the actual indicator dial. Enter this number into the backlash compensation table.

If the axis will perform the above test, the compensation for that axis is complete. Repeat for the Y axis.

### 9.8.3 Entering Backlash Compensation Values

To enter backlash compensation values, go to the Main Menu and select (F10) Parameters.
Cursor down to the appropriate axis and enter the value.

# CHAPTER 10. Head Assembly

## 10.1 LUBRICATION

All bearings and gears in the head are lubricated for life; bearings are lubricated with BRB lifetime grease and the back gears with Sunoco No. 741 E.P. grease or Mobil Lux No.1 E.P.

The automatic lubrication system used to lubricate the table, saddle, and knee also lubricates the ball quill extension. Periodically fill the reservoir (located in the back cabinet on the column) with Sunoco Waylube No. 80 or equivalent.

The V2XT machine must have its Hl-LO sleeve lubricated every six months. Remove the 5/16-24 setscrew labeled "A" from the left side of the clutch bracket (49), Figure 10-1. Squeeze in approximately one-half teaspoon of Lubriplate No. 107.

## 10.2 PROGRAMMABLE SPINDLE SPEED

The programmable spindle speed control provides the means to automatically change the spindle speed within a gear range. This consists of a potentiometer (mounted to the speed changer drum) and a proximity sensor to indicate the gear high or low position.

**NOTE**

Excess wear on the vari-drive belt will cause a slight increase in actual speed as compared to that shown on the dial. The speed control can be reset by the following procedure. Refer to Figure 10-1.

1. With the spindle rotating, turn the variable speed control snugly against the high speed stop (4200 reading on dial). Loosen the jam nut and turn the pivot pin at the top of the head. Use a tachometer to set the spindle speed at 4200 rpm. Tighten the jam nut.
2. Place the HI/LO gear shift in low gear.
3. Adjust the gear select cable so a l/64-inch gap exists between the sensor and target.
4. Unscrew two 10-32 x 1.625 inch socket head cap screws to remove the speed sensor cover (located at the front top of the head). Slightly loosen two clamp screws securing the speed sensor cable.
5. Move the gear shift lever to place the machine in high gear. Turn on the spindle.

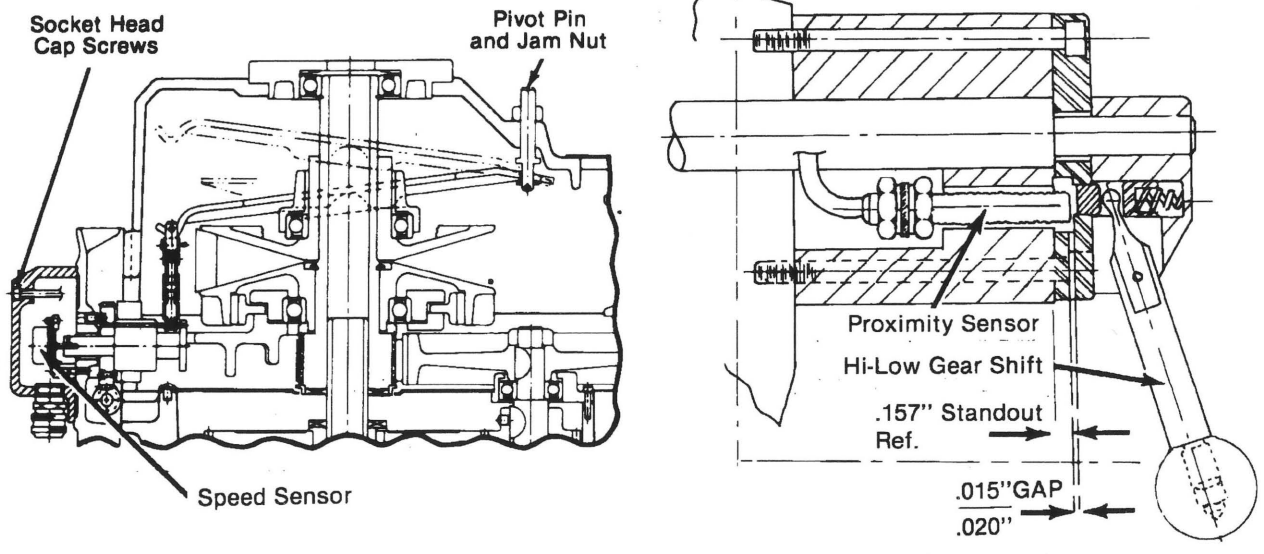



**Figure 10-1.** Setting Speed Control

# 10. Head Assembly

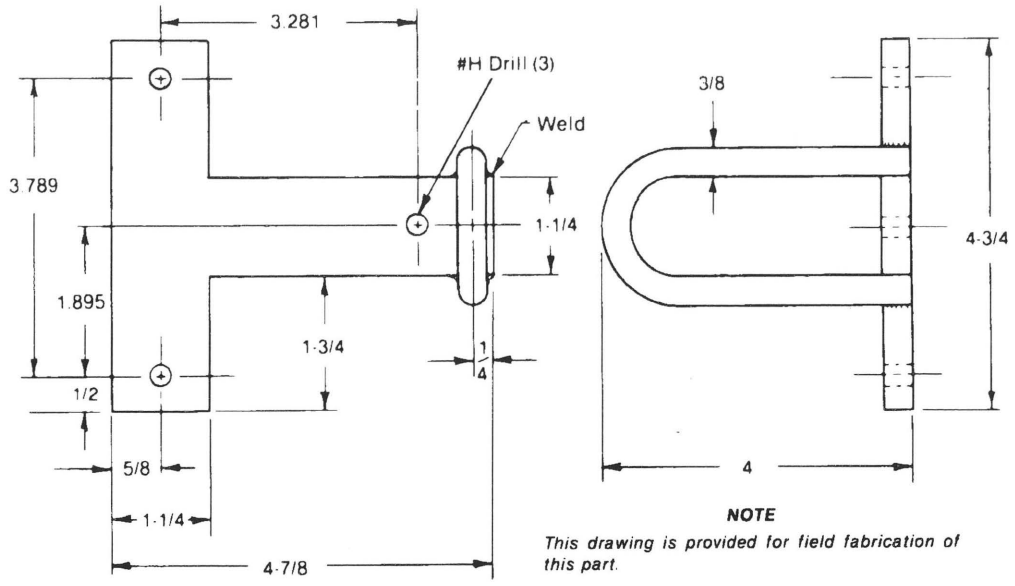



**Figure 10-2.** Special Tool ST-6921 Headlift Bracket

6. Press the speed increase button until the CRT displays and rpm reading exceeding 4200.
7. Slowly turn the speed sensor counterclockwise until a CRT reading of 4200 ± 100 rpm is obtained. Tighten the two clamp screws on the sensor.
8. Press the speed decrease button on the panel to bring the CRT rpm reading down to 500 ± 100.
9. Check the speed control adjustment by pressing the Speed Increase button until a maximum reading is obtained. If the CRT reading is 4200 ± 100, the speed control is properly set.
10. If the CRT reading is not 4200 ± 100 rpm, repeat Steps 5 through 9 until this reading is obtained.

**NOTE**

When the belt is worn to the extent that accurate speed adjustment is no longer possible, the belt must be replaced. See Section 10.2.4.

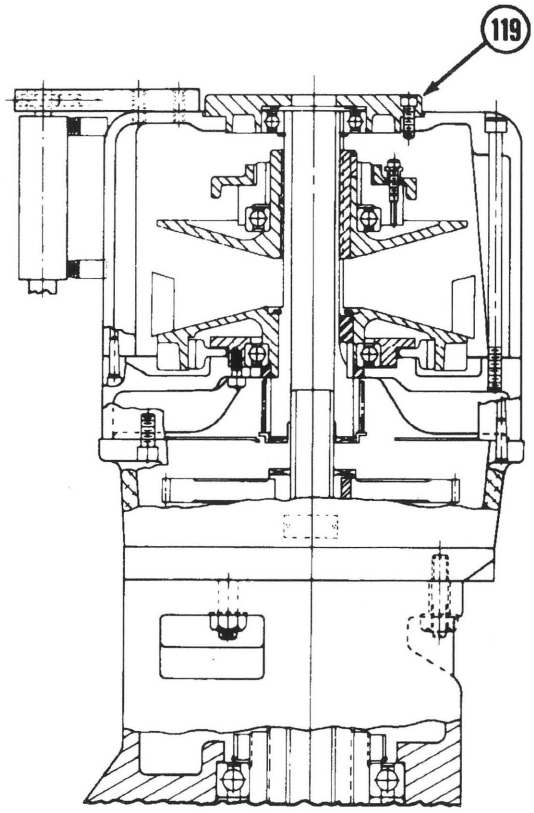



**Figure 10-3.** Head Removal

# 10. Head Assembly

### 10.2.1 Head Removal (Figures 10-2 and 10-3)

Disconnect the power to the machine. Failure to do so may result in serious personal injury or death.

1. Disconnect power to the machine. Remove the electrical cable from the spindle motor by removing the cover of the electrical connection box and disconnecting the wires. Be sure to label the wires properly to ensure correct reassembly.
2. Disconnect the head lube line at the Bijur lubricator pump. Free the line and secure it to the head.
3. To remove the quill limit switch and cable assembly, remove the two screws securing the cover to the quill housing and the eight screws securing the microswitches and their mounting brackets to the quill housing.
4. Remove the quill drive motor. See Section 10.3.3, Steps 1 through 7.

**NOTE**

The head should now be clear of all electrical connections.

5. Attach the head lifting tool (ST-6921), Figure 10-2, to the belt housing bearing cap (119), Figure 10-3, using three 0.250-20 x 0.750 screws. The loop in the lifting tool should be over the center of gravity of the head.
6. Support the head with an overhead hoist through the loop of the lifting tool.
7. Remove the four remaining bolts securing the head to the ram.
8. After reassembly, make the following adjustments:
   a. Z+ overtravel switch adjustment, see Section 10.2.
   b. Deceleration home switch adjustment, see Section 10.4.
   c. Z- overtravel limit switch adjustment, see Section 10.4.
   d. Quill drive belt adjustment, see Section 10.3.4.

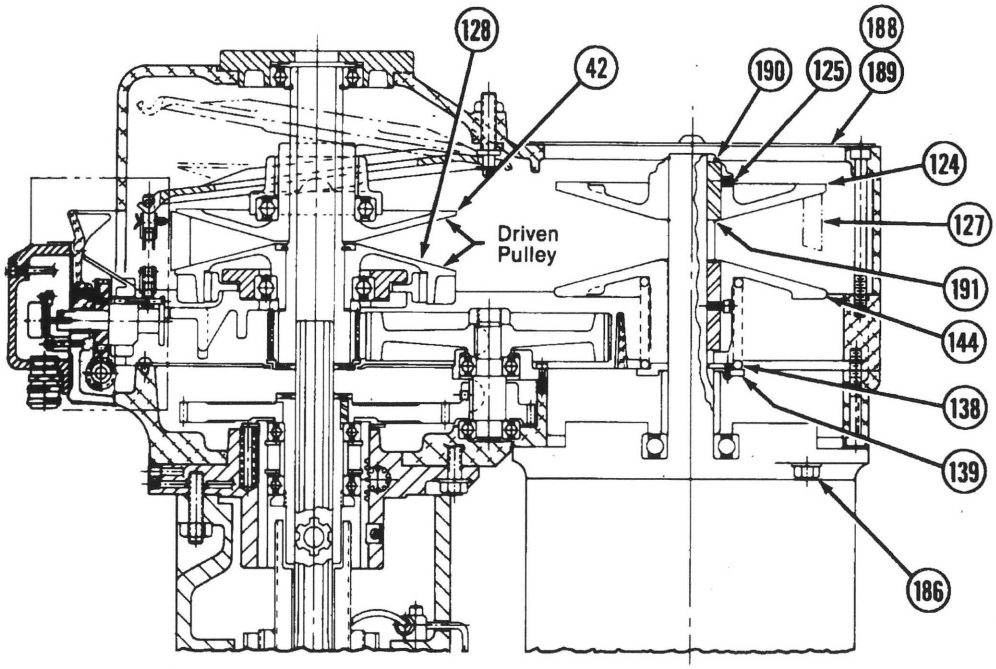



**Figure 10-4.** Motor Removal

### 10.2.2 Motor Removal (Figure 10-4)

1. With the motor running, adjust the variable speed control to the top of the speed range. Adjust the speed changer into the red zone until the mechanical stop in the speed changer is reached. This adjustment may be made in either the high or low speed range. The variable speed belt is now in the proper position for motor removal.

**NOTE**

It is essential to adjust the speed range before proceeding to Step 2.

2. Shut down the motor.
3. Disconnect power to the machine. Remove the electrical cable from the motor.
4. Loosen, but do not remove, the three binding bolts on the right side of the ram yoke. Turn the worm gear shaft bolt at the top of the ram adapter, tilting the head forward. When the head is tilted enough to facilitate the motor removal, tighten the three binding bolts to the required torque of 50 pound feet.
5. Remove two screws (189) and the motor pulley cover (188).

**NOTE**

If Step 1 was done correctly, the drive belt (127) will ride toward the outside edge of pulleys (124) and (144). If this condition does not exist, reassemble the head and correctly perform Step 1. B. Remove the retaining ring (190).

7. Loosen socket set screws (125) and remove pulley (124).

**WARNING**

Be prepared for the pulley to spring up approximately one-half inch when the socket set screw is loosened.

8. Compress the lower pulley (144) on the motor shaft until the pressure is relieved from the retaining ring (191); remove the ring. Lift the lower pulley, compression spring (138), and collar (139) off the motor shaft.

**WARNING**

The motor weighs approximately 60 lbs. Take appropriate precautions to prevent equipment damage and possible personal injury.

9. Support the motor and remove the two screws (186) securing the motor to the variable speed housing. Remove the motor from the housing.
10. Reverse this procedure to reassemble. Retaining ring (191) is easily damaged during removal and may need replacement.
11. Difficulty may be encountered when assembling the pulley (124). First, work the belt as far toward the center of the driven pulley (42 and 128) as possible. Next, work the belt as far as possible toward the outer edges of the drive pulleys (124) and (144). Apply pressure to lower the pulley (124) until the retaining ring (190) can be assembled. A small plastic mallet may be used to tap the pulley into place.
12. Trammel the spindle after reassembly.

### 10.2.3 Vari-Drive Belt Replacement (Figure 10-5)

1. Follow Steps 1 through 3 and 5 through 7 in Section 10.2.3.
2. Remove the top bearing cap (119), two screws (120), and the pivot pin (134) and screw (135) securing the speed changer plate (101) to the bearing housing (41).
3. Remove the two screws (100) under the speed changer dial holding the speed changer housing to the belt housing base.
4. Remove three screws (95) and two screws (96) securing the belt housing (97) to the belt housing base (98). The belt housing is held in place by two taper pins.

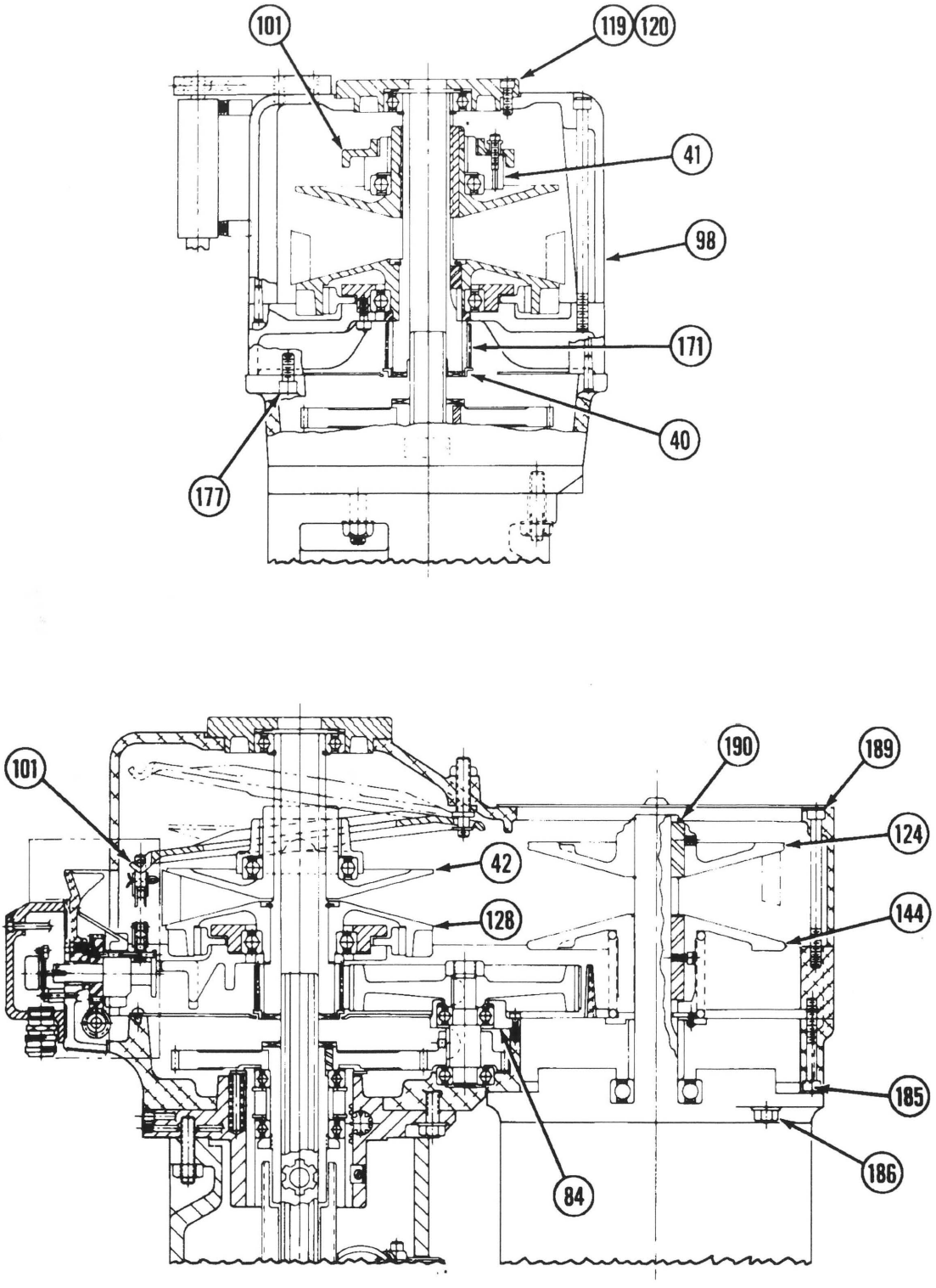



**Figure 10-5.** Vari-Drive and Timing Belt

5. Lift the belt housing, with the speed changer bracket attached, off the taper pins and separate it from the belt housing base. To facilitate this step, tap upward on the speed changer housing with a plastic mallet. Several blows may be necessary to loosen the two housings.
6. Remove the old belt and replace it with a new one.

CAUTION

Only replace with a belt purchased from a Bridgeport Representative. The wrong belt may cause vibration and overheating.

7. Reverse this procedure to reassemble. (Use Locktite #242 when reassembling.) You may have difficulty when assembling the pulley (124). First, work the belt as far toward the center of the drive pulleys (42 and 128) as possible. Next, work the belt as far as possible toward the outer edges of the drive pulleys (124) and (144). Apply pressure to lower the pulley (124) until the retaining ring (190) can be assembled. A small plastic mallet may be used to tap the pulley into place.

### 10.2.4 Timing Belt Replacement (Figure 10-5)

1. Lower the quill.
2. Follow Steps 1 through 3 and 5 through 8 in Section 10.2.3.
3. Put the HI-NEUTRAL-LO lever on the right side of the head in the LO position.
4. Remove the two lower screws (100) in the speed changer housing.
5. Remove the two screws (177) and three screws (185) holding the belt housing base (98) to the gear housing (84). Two taper pins hold these parts together. To separate the two housings, tap upward on the speed changer housing with a plastic mallet. Several blows may be necessary to loosen the two housings.
6. The two upper screws (100) on the speed changer housing should be loosened after the belt housing has been separated from the gear housing.
7. Gently disengage the timing belt (171) from the pulley (40) as the belt housing is being raised.
8. Remove the old belt and replace it with a new one.

CAUTION

Only replace with a belt purchased from a Bridgeport Representative. The wrong belt may cause vibration and overheating.

9. Reverse this procedure to reassemble. You may have difficulty assembling the pulley (124). First, work the belt as far toward the center of the driven pulleys as possible. Next, work the belt as far as possible toward the outer edges of the drive pulleys (124) and (144). Apply pressure to lower the pulley (124) until the retaining ring (190) can be assembled. A small plastic mallet may be used to tap the pulley into place.

## 10.3 QUILL AND SPINDLE

### 10.3.1 Spindle Locknut Assembly (Figure 10-6)

1. Remove three screws from the locknut.
2. Screw on the nut assembly as far as possible—then back off one turn.
3. Insert a standard Quick Change Adapter and tighten the locknut.
4. Screw in longest button head screw (dog point) in the hole permitting the greatest amount of rotation for unlocking. (This is usually the hole closest to a locking ear.)
5. Rotate the nut back to load position (locking ears and keys are in line.).
6. Insert cadmium-plated screw in the hole in line with the locking ear; this identifies the screw to enable the operator to load adapters properly.
7. Put the remaining screw in the remaining open hole. The spindle is now ready to use.

### 10.3.2 Spindle Removal (Figure 10-7)

1. Lower the quill one inch from the Z - overtravel position (Z = -4.000).
2. Remove the spindle nose set screw located on the quill outside diameter.
3. Move the quill to the Z+ overtravel position. Lower the knee to the Z- overtravel position.
4. Place blocks under the spindle to prevent it from dropping when loosened from the quill. Remove the spindle nose locknut from the quill.
   The spindle is now free to be removed from the quill.

**WARNING**

To prevent serious injury, do not have hands between the spindle and support blocks. When the spindle bearings clear the bore in the quill, the spindle will rapidly drop out of the quill.

5. If the spindle does not drop out, tap on the end of the spindle with a small plastic mallet through the opening on the top of the variable speed assembly. This will force the spindle bearing out of the bore of the quill.

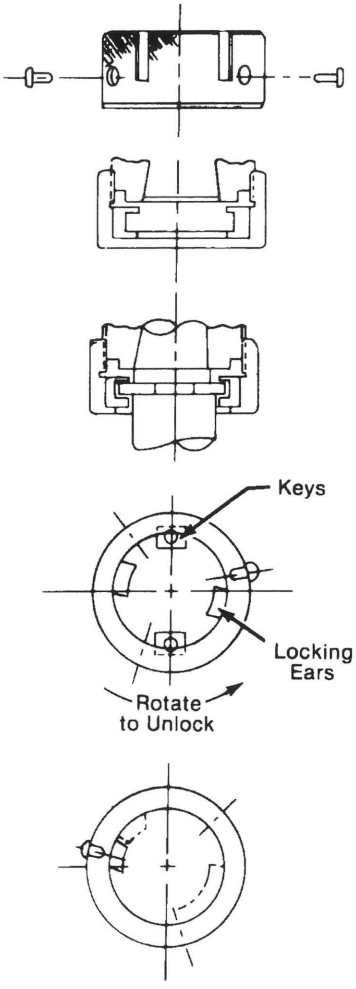



**Figure 10-6.** Quick Change Locknut Assembly

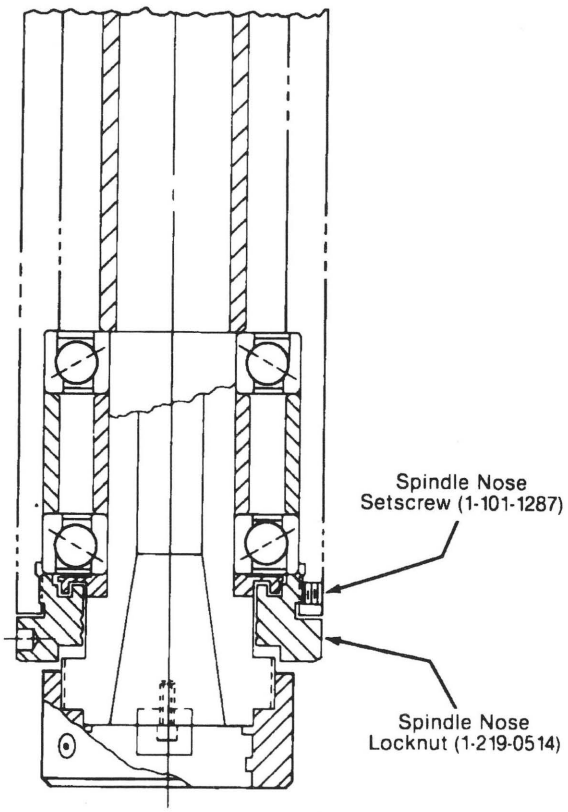



**Figure 10-7.** Spindle Removal

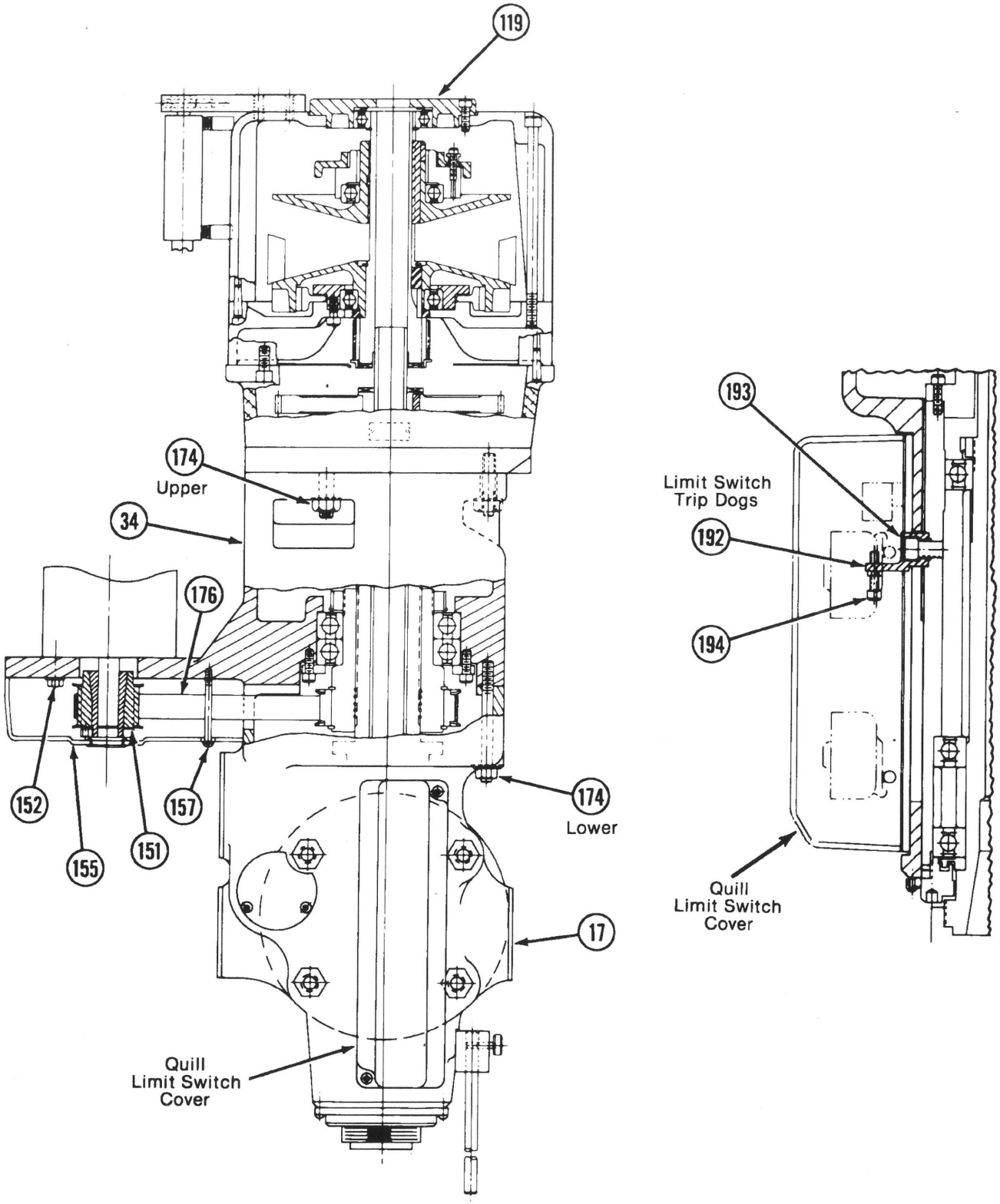



**Figure 10-8.** Quill Drive

### 10.3.3 Quill Drive Motor Replacement (Figure 10-8)

1. Disconnect power to the machine by throwing the main circuit breaker to the OFF position.
2. Remove the cable from the motor and encoder.
3. Remove three screws (157) and remove the Z-axis drive motor cover (155) from the drive bracket (34).
4. Remove four screws (152) holding the drive motor to the drive motor bracket (34).
5. Slide the timing belt (176) off the motor pulley assembly (151).
6. Remove the motor pulley assembly by loosening the set screws. Then use three 10-32 socket head cap screws to pull the bushing toward the collar. Slide the pulley assembly off the motor shaft.

CAUTION

Do not disassemble the motor. Magnetic characteristics of the motor are destroyed if the armature is removed. Care should be taken when removing the motor. Approximate weight is 10/lbs.

7. Lift the drive motor off the drive motor bracket (34).
8. Install the replacement motor.
9. After the drive motor is installed, set the proper belt tension; see Section 10.3.4.
10. Connect the motor and encoder cables. Refer to section 10.4 to set limit.

### 10.3.4 Quill Drive Belt Adjustment (Figure 10-8)

1. Remove three screws (157) and remove the Z-axis drive motor cover (155) from the drive bracket (34).
2. Loosen, but do not remove, four screws (152) securing the drive motor to the drive motor bracket (34).
3. Adjust the belt tension. Pulling the motor away from the head will increase the belt tension. Pushing the motor toward the head will decrease the tension.

**NOTE**

The belt should have a tension of 66 lbs.. or should deflect, in the middle of one side, 1/8 inch with 5 lbs. force applied.

Tighten the four motor mounting screws when the proper tension is obtained.

### 10.3.5 Quill Drive Belt Removal (Figure 10-8)

1. Lower the quill two inches from the Z+ overtravel position.
2. Disconnect power to the machine by throwing the main circuit breaker to the OFF position.
3. Follow the procedure for drive motor replacement, Section 10.3.3, steps 2 through 7.
4. Disconnect electrical wiring from the spindle drive motor.
5. Attach head removal tool (ST-6921), Figure 10-2, to the bearing cap (119) using three 0.250-20 x 0.750 in. Special Tools screws.
6. Support the head with a hoist attached to the removal tool.
7. Remove the upper three hex nuts (174) securing the variable speed assembly to the drive motor bracket (34); then lift the variable speed assembly.
8. Remove two screws; then lift the quill limit switch cover off the quill housing.
9. Remove screw (193). Lift quill switch trip-dog (192) out of the quill.
10. Disconnect the lubrication line from the drive motor bracket.
11. Support the drive motor bracket and remove the lower three hex nuts (174).

CAUTION

When the quill is out of the quill housing bore, do not let it rotate. If the ballnut is allowed to rotate off the ball quill extension shaft, the ball quill extension shaft and ballnut will have to be replaced.

The ball quill extension assembly when exposed to the open air, must be kept free of dirt, dust, chips, and oil. The area must be free of any contaminating equipment.

12. Carefully lift the drive motor bracket off the quill housing (17). The quill will be removed with the quill housing.
13. Replace the quill feed belt (176).
14. Before installation, the quill bearing surface and the quill housing bore must be free of any foreign material.

**NOTE**

Upon reassembly, torque all bolts evenly and ensure mating surfaces are completely clean. Grease splines. If clutch face disengagement is difficult, it will be caused by misalignment between the top and bottom halves of the head. See Section 10.5.

15. Refer to Section 10.5 for alignment of the drive motor bracket to the quill housing and alignment of the variable speed assembly to the drive motor bracket.
16. Install the drive motor and connect motor and encoder cables.
17. Connect the electrical wiring to the spindle motor.
18. After the assembly is complete, perform the following settings:
    a. Set the quill drive belt tension, Section 10.3.4.
    b. Check and reset the quill limit switches, if necessary:
        1) Z+ overtravel limit switch, Section 10.4.
        2) Deceleration home switch, Section 10.4.
        3) Z- overtravel limit switch, Section 10.4.

### 10.3.6 Ball Quill Assembly Removal (Figure 10-9)

**Special Tools**

ST-6921, Figure 10-2
2-inch adjustable spanner wrench
2-inch adjustable hook spanner wrench

**Procedure**

1. Follow the disassembly procedure for the quill drive belt removal, Section 10.3.5, Steps 1 through 12.
2. Remove six screws (194) and separate the quill spindle assembly from the ball quill assembly (28).
3. Remove four screws (38) and bearing retainer (35).

CAUTION

Do not press on the ballscrew or the balls will dent their housing, destroying the ballscrew assembly.

4. The ball quill assembly, including bearings, should be pressed out of the drive motor bracket (34). Press between the hex nut (44) and bracket (34).
5. Bend the lockwasher tab (45) down. Use a 2-inch adjustable spanner wrench and a 2-inch adjustable hook spanner wrench to remove the locknut (44) and lockwasher. Remove bearings (29).

**NOTE**

The bearings must be reinstalled in the same orientation as they were. Use the "V" on the outside diameter of the bearings as your guide for reinstallation. Note the bearing shields are toward the outside.

6. Remove the set screw (37) and snap ring (39) located on the outside diameter of the pulley (40).

**CAUTION**

Do not remove the ball quill extension nut from the ball quill extension shaft.

7. Slide the pulley (40) and the key (36) off the ball quill extension nut.
8. The ball quill assembly (28) is now completely disassembled.
9. Before installation, inspect and clean the ball quill extension assembly; see Section 10.6.2. Also check the ball quill assembly preload, see Section 10.6.1.

**NOTE**

CLEANLINESS is of great importance in this procedure. Before installation of the quill, the quill bearing surface and the quill housing bore must be free of any foreign material.

10. Assemble pulley (40), key (36), set screw (37), and snap ring (39) to the ball quill nut.
11. Install bearings (29), lockwasher (45), and locknut (44). The spanner wrench should be tapped lightly to tighten the locknut on the ball quill nut. Insert the lockwasher tab in the locknut.

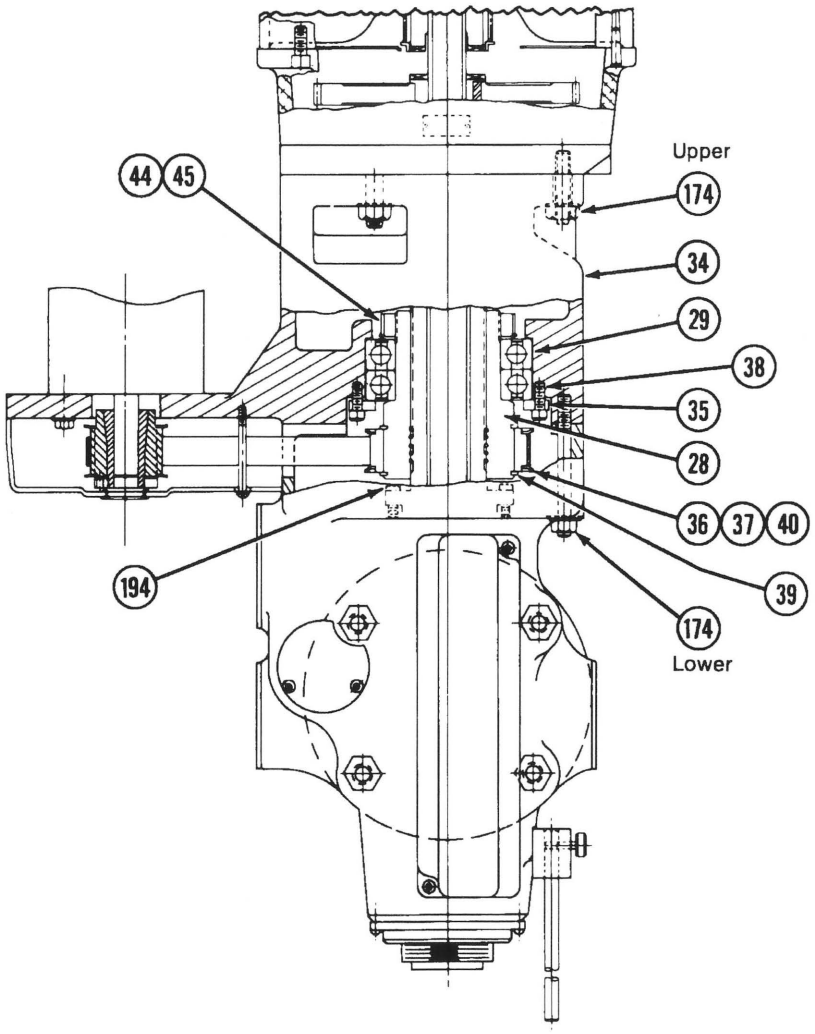



**Figure 10-9.** Ball Quill

12. Install the ball quill assembly (28) in the motor bracket (34). Assemble the retainer (35) and four screws (38).
13. Assemble the quill/spindle assembly to the ball quill assembly using six screws (194).
14. Follow Steps 13 through 18, Section 10.3.5.

### 10.3.7 Quill Removal (Figure 10-9)

CAUTION

The quill outside diameter and the quill housing bore are a matched fit. The only occasion a quill should be removed is in the event of severe damage by scoring through lack of lubrication or other causes.

1. Follow Steps 1 through 12, Section 10.3.5.
2. Remove six screws (194) and separate the quill and spindle assembly from the ball quill assembly (28).

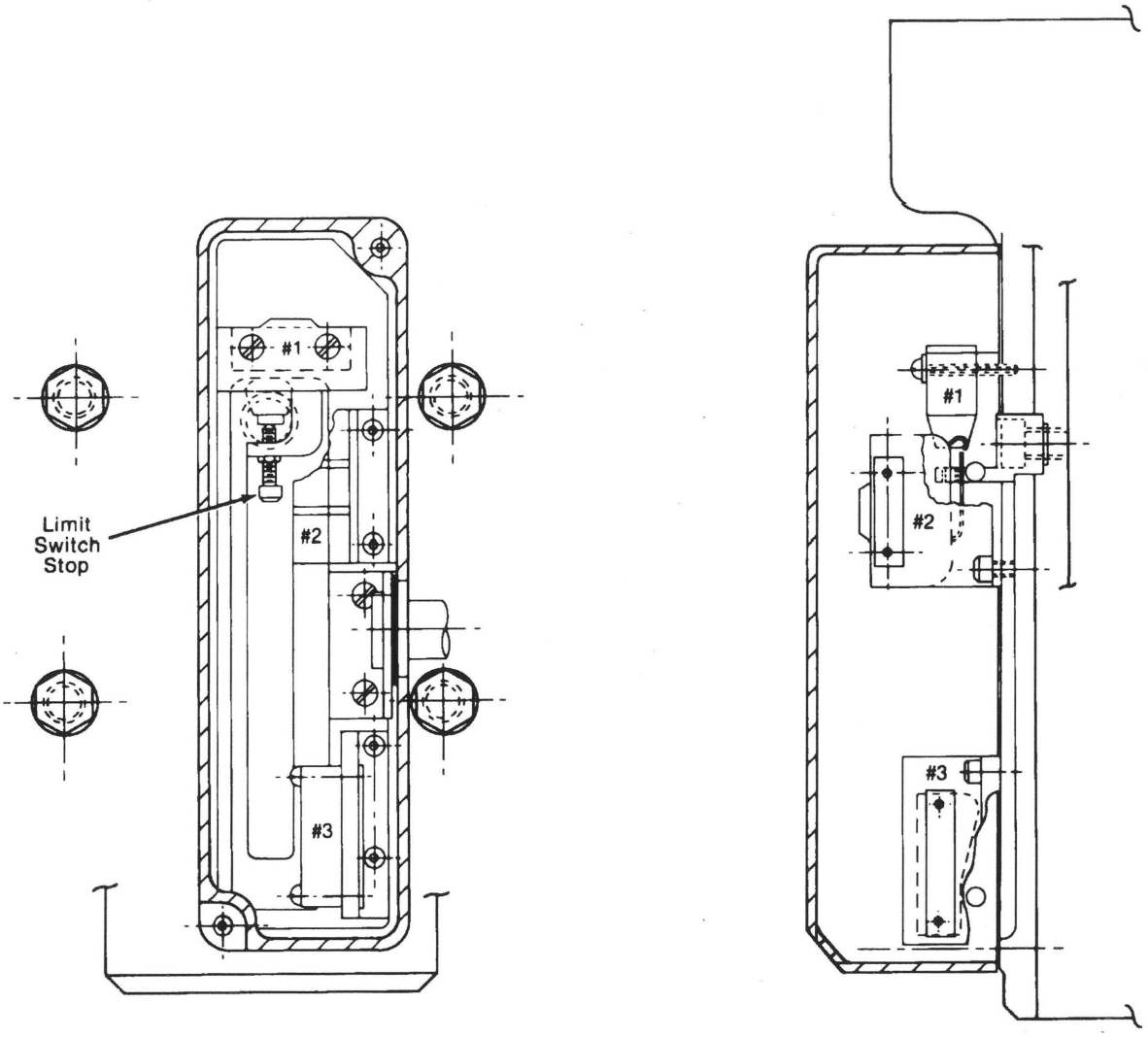



**Figure 10-10.** Limit Switches

## 10.4 QUILL LIMIT AND DECELERATION SWITCH SETTINGS (Figure 10-10)

**WARNING**

Some movement of the spindle motor may occur. Adjust the pulley belt carefully to avoid machine damage and possible personal injury.

1. Loosen the pulley on the Z axis motor assembly. (refer to Section 10.3.3.).
2. Using the Z-axis pulley crank the quill up to the mechanical limit. Then crank the quill down 4 complete turns at the motor pulley. The quill is at the correct revolution to activate the home switch.
3. Turn on the control. Hit button 2 to go to system terminal.

**NOTE**

Ensure that Port A is jumpered to port B.

4. Hold down the CTRL button and hit the letter button 0. The display should read "Line Feed Off".
5. Press V button. The SAF registers are now displayed. The Z-axis home bit is in register D3. Trip the switch and note the bit change.
6. Set the home switch so that this bit just changes.
7. Hit ESC button and then the F2 button. Then hit button 1 follow by button 3 to go to the jog page. Select Z-axis jog knob. 1 in per rev. by hitting button 9 and 6.
8. Go back to system terminal by hitting number button O twice followed by a 2.

9 Select the Z-axis registers display by hitting the Z button. The last register to the right will display the Z-axis displacement from home. Using the jog knob, set this register to read 2850.

10. Tighten the pulley onto the Z-axis motor shaft.
11. Go to the SAF register display by hitting the ESC and the V button.
12. Jog the Z-axis down off the home switch and then slowly back onto the home. Observe data register D3 for the change of status.
13. Go to the Z-axis display by hitting the ESC and the Z button. The axis displacement register should read between 2800 and 2900.
14. If it does the home switch is set up. If it does not, set the axis displacement register to 2850. Go to the SAF register display and readjust the home switch.
15. Repeat 12 and 13 until the correct reading is obtained in step 13.

### 10.4.1 Setting the Z-Axis Limit Switches.

1. After completing 10.4, Go to the set up page and home the machine.
2. Loosen the nut that locks the quill limit switch adjustment. Adjust the bolt slowly up until the control trip into Z-axis limit. Turn the bolt counterclockwise 1 full turn and tighten the lock bolt.
3. To adjust the lower limit switch, hold the upper limit closed.
4. Exit from the system terminal by hitting the ESC and F2 buttons. Enable the axis drive by hitting button 7.
5. Go to jog by hitting button 1 and 3. Select Z jog knob by hitting buttons 9 and 6.
6. Go back to the system terminal and select the Z-axis display by hitting the number button 0 twice, the 2 button and Z button.
7. Using the jog knob, jog the Z-axis down until the axis 2 displacement reads 50300.
8. Go to SAF register display by hitting the ESC and the V button. Adjust the quill down limit switch while observing the D3 registered for the switch closure.
9. Check the quill down for 5 inches of travel.

### 10.5 ALIGNMENT OF QUILL HOUSING TO DRIVE MOTOR HOUSING (Figure 10-8)

Perform this procedure whenever the motor mounting bracket (34) has been removed.

1. The quill outside diameter and the quill housing bore should be meticulously clean and lightly oiled upon assembly.
2. Install the three lower hex nuts (174) securing the quill housing (17) to the drive motor bracket (34), but leave them loose.
3. Install the limit switch trip dog with screw.
4. Use the belt (176) to move the quill up and down along its travel and return to home position. This should allow the drive motor bracket (34) to float and align itself with the quill housing. Lock the three lower hex nuts (174).
5. Check for proper alignment; tie a string around the belt and tie a measuring scale on the end of the string. Pull on the scale, moving the quill up or down to obtain a reading.
6. Repeat this procedure to obtain a reading over the entire up and down travel of the quill.
7. Minimize the reading on the scale by repeating steps 4 and 6.
8. Place the upper head assembly on the drive motor bracket and put the three upper nuts (174) loosely into place. Take care not to damage the splines on the spindle or gear hub.
9. Repeat steps 4, 5, and 6 to float the upper head assembly into place.
10. Tighten the three upper nuts (174).
11. The reading on the scale with the quill moving up should not exceed 40 ounces maximum pull. The reading on the scale with the quill moving down should not exceed 28 ounces maximum pull.

### 10.6 BALL QUILL ASSEMBLY

**WARNING**

CLEANLINESS is of great importance during this operation. Operator's hands and clothing must be free of any dirt and oil. Test equipment, fixtures and tables must be free of dirt, dust, chips, and oil. The inspection area must be free of any air contaminating equipment, such as grinding machines, exhaust blowers, etc.

| Quill Nut Travel | Scale Reading (Pull) |
|---|---|
| Up | 18 oz. Max. |
| Down | 18 oz. Max. |

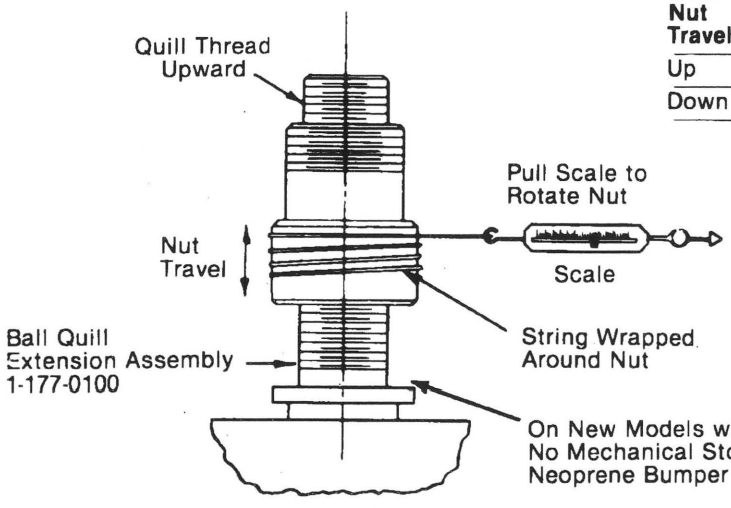

Quill Thread Upward
Pull Scale to Rotate Nut
Nut Travel
Scale
Ball Quill Extension Assembly 1-177-0100
String Wrapped Around Nut
On New Models with No Mechanical Stop Neoprene Bumper

**Figure 10-11.** Ball Quill Extension Torque on Nut Setup

### 10.6.1 Ball Quill Assembly Preload Torque on Nut (Figure 10-11)

1. The ball quill assembly shaft and nut must be free of any foreign material.
2. Set the ball quill assembly in an upright position, with the ball threads facing upward and the mounting flange downward.
3. Wrap a string around the ballnut's large outside diameter (pulley mounting diameter).
4. Tie a measuring scale on the end of the string.
5. Pull on the scale, rotating the quill nut, to obtain a reading.
6. Repeat this procedure to obtain a reading over the entire up and down travel of the ballnut on the ball shaft.
7. The reading on the scale with the nut moving up should not exceed 18 ounces maximum pull. The reading on the scale with the nut moving down should not exceed 18 ounces maximum pull.
8. If the scale readings exceed the limits or any excessive drag or nut hang up is on the shaft, clean and flush the ballnut and shaft.
9. If after cleaning the nut the scale readings are still over the limits or a drag or hang up still exists, replace the ball quill assembly.

### 10.6.2 Cleaning and Flushing the Ball Quill Extension Assembly (Figures 10-12 and 10-13)

1. Set the ball quill assembly in a horizontal position and place over a flushing tank (Figure 10-12).
2. Pour an oil-dissolving solvent over the ball threads and ballnut. This will remove any contaminated oil, chips, or foreign material from the ball quill extension assembly. Remove from the flushing tank.
3. Set the ball quill assembly in an upright position in a container, with the ball threads facing upward and the mounting flange downward, (Figure 10-13).
4. Pour an oil-dissolving solvent over the ball threads and into the top of the nut while rotating the nut over its total travel. This will remove any contaminated oil on the threads and flush any chips or foreign material lodged in the ballnut tracks.
5. After cleaning, apply a film of light machine oil over the threads and into the ballnut.

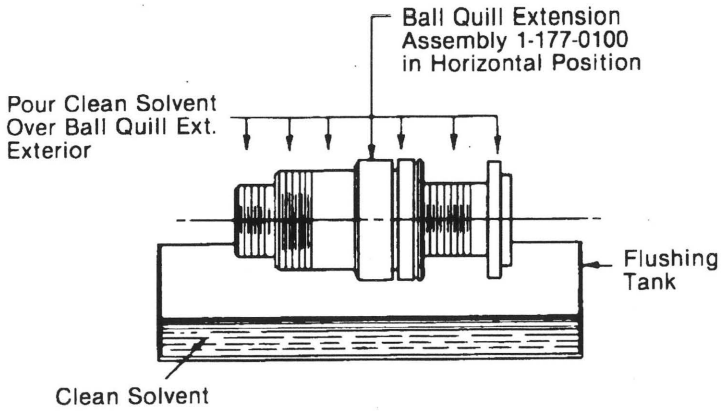



**Figure 10-12.** Ball Quill Extension Flushing

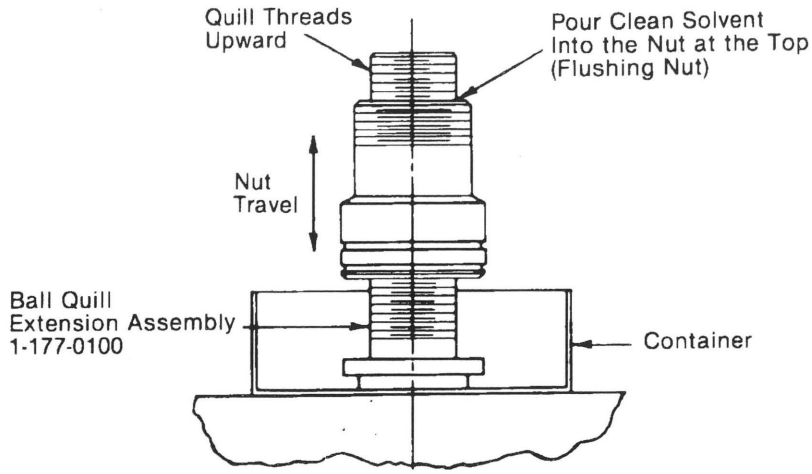



**Figure 10-13.** Ball Quill and Nut Flushing

### 10.7 INSTALLATION OF PNEUMATIC BRAKE (Figure 10-14)

1. Install the stud (2) into the hole on top of the belt housing cover.
2. Loosen the hex nut (8) and washer (9). Slide the cylinder bracket (1) over the stud.
3. Attach the adjustment coupling (15) to the brake lock shaft (12) with a socket head cap screw (6B).
4. Attach the lever (5) to the adjustment coupling (15) with a socket head cap screw (6C). Attach the lever to the clevis (4) on the cylinder (3) with a shoulder screw (7) and a self-locking nut (11).
5. Position the cylinder so it is in a vertical position and check for free movement of the lever and clevis.
6. Locate the position for the cylinder bracket mounting screw (6A).
7. Remove the cylinder bracket and drill and tap a 0.250-20 inch hole through the belt housing cover.
8. After the hole is tapped, slide the cylinder bracket over the stud and attach it to the belt housing with a socket head cap screw (6A) and washer (10).

**NOTE**

If the pneumatic speed changer is to be installed also, the 0.250-20 inch tapped hole may be drilled when the belt housing cover is removed. See pneumatic speed changer installation instructions for removal of belt housing cover. If belt housing cover is not removed, use a vacuum when drilling and tapping the 0.250-20 inch hole to collect the metal chips.

### 10.8 PNEUMATIC SPEED CHANGER REPLACEMENT (Figure 10-15)

1. Adjust the spindle speed to high rpm. High setting moves the speed changer plate (101) to an upward position, facilitating access to the speed changer.

Disconnect all power to the machine. Failure to do so may result in electric shock, causing serious personal injury or death.

2. Detach the bearing cap (119) by removing three socket head cap screws.
3. Remove two socket head cap screws securing the speed changer plate to the bearing housing (41).

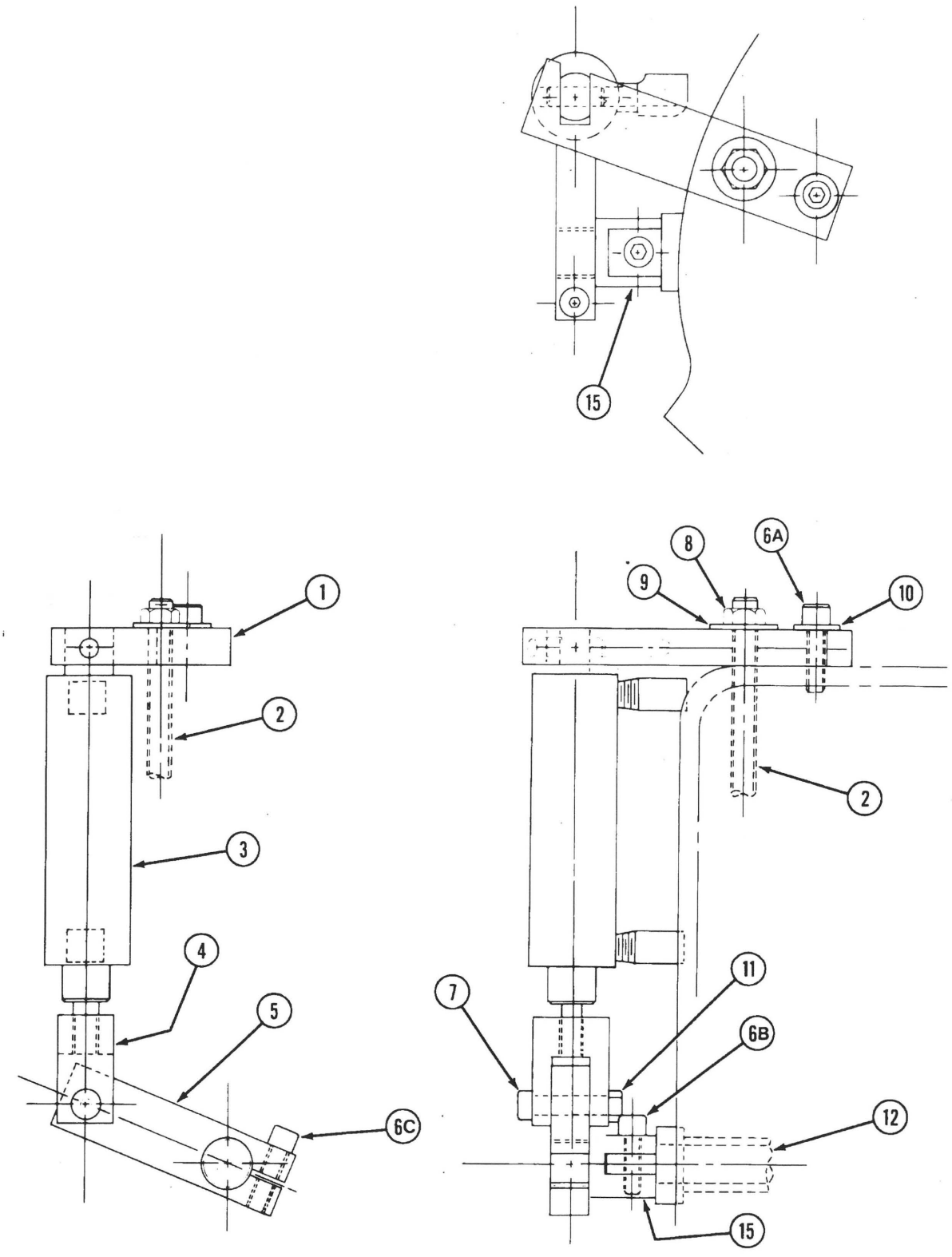



**Figure 10-14.** Pneumatic Brake

4. Remove the motor pulley cover (188) by unscrewing two button head cap screws.
5. Remove the retaining ring (190). Loosen the socket set screw (125), and slide the pulley off the motor shaft to relieve pressure on the drive belt.
6. Remove two flat head machine screws (46) securing the speed changer cover (45). Detach the cover.
7. Unscrew two lower screws (100) under the speed changer dial to free the speed changer housing from the belt housing base.
8. Remove three screws (95) securing the belt housing (97) to the belt housing base (98).
9. Remove the screw, nut, and washer (holding the pneumatic brake) located at the top front of the upper belt housing (97).
10. Carefully lift the speed changer assembly and the entire upper housing from the machine.
11. Remove the cotter pin (105) and washer (104) from the adjustment screw.
12. Remove two upper screws (100) over the speed changer dial.
13. Push the roll pin (30), located at the end of the chain stud (29), to one side. Carefully remove the speed changer from the belt housing.

Reverse this procedure to replace the speed changer.

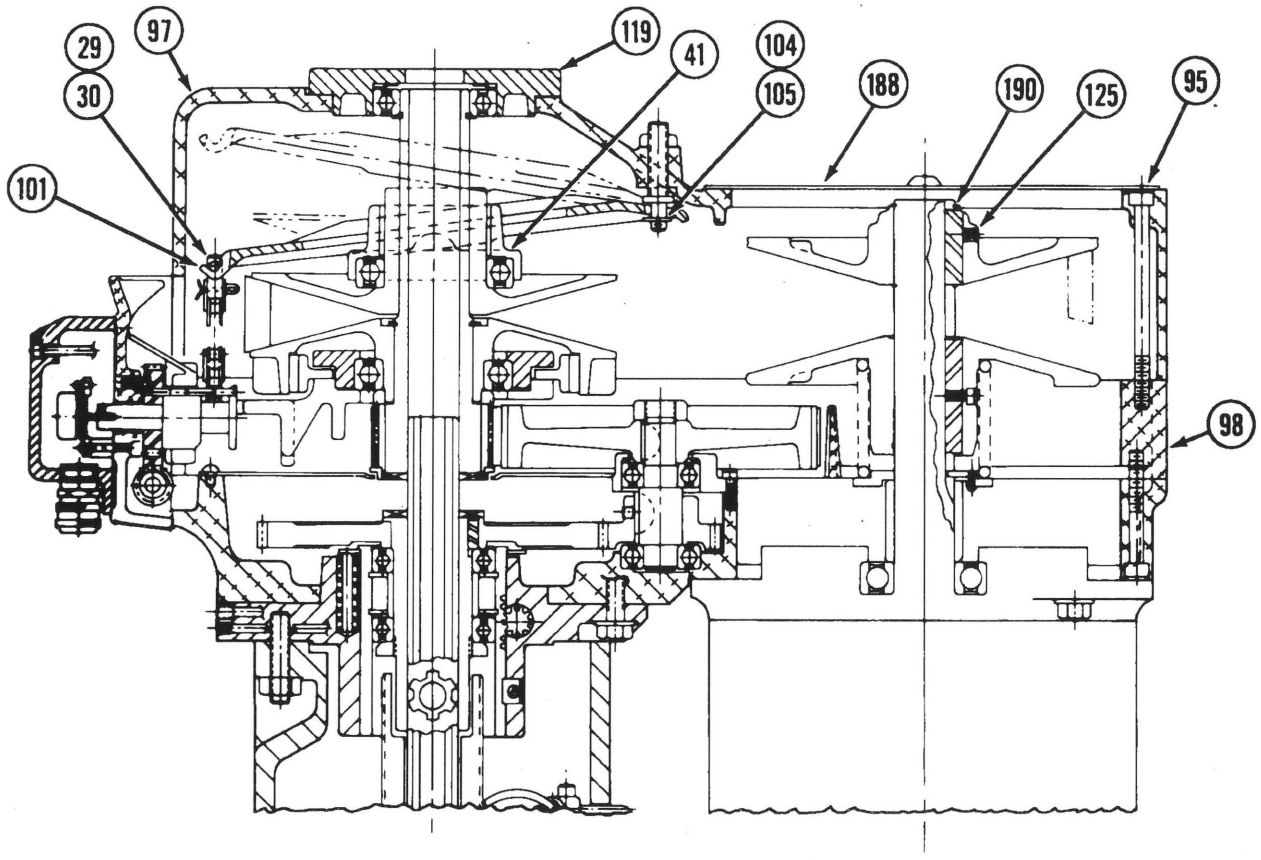



**Figure 10-15.** Pneumatic Speed Changer Replacement

# CHAPTER 11. Auxiliaries

## 11.1 INTRODUCTION

The first section of this chapter supplies general information concerning the V2XT milling machine auxiliaries system. The following pages provide adjustment procedures and parts replacement information for the pneumatic and lubrication systems in the V2XT milling machine. Vendor information, specifications and replacement part numbers are also included.

## 11.2 PNEUMATIC SYSTEM

### 11.2.1 Speed Changer and Brake

Pneumatic system contains a filter/regulator with a drain and a lubricator. There is also a manifold that controls air flow to the pneumatic motor and spindle brake. There are two kinds of valves used:

Single solenoid, 4 way, 2 position, for Brake and Index (Options)

Double solenoid, 4 way, 3 position, for Speed Changer

The air is lubricated with a small amount of oil. The flow of oil is controlled by a knob on the top of the filter/lubricator. To set the air flow, turn the knob clockwise to OFF then counterclockwise to ON approximately 1/2 turn (3/4 turn is full flow). See Chapter 12 Parts Breakdown for details.

**CAUTION**

Do not operate the system with the air lubricator valve OFF. This will cause the hoses to deteriorate over a period of time.

There is one type of lubricant approved for use in the pneumatic system of machines so equipped: Mobil DTE24 or direct equivalent, refer to Specification Sheet 1-037-001 in this chapter. See Parts Breakdown, Chapter 12. for pneumatic schematic.

## 11.3 LUBRICATION SYSTEM

### 11.3.1 Overview

The bearings in the spindle, the spindle drive transmission, and the ballscrew mountings have antifriction angular contact bearings greased for life.

The moving members are all fed from a central lubricating tank, the TM-5 lubricator, which contains a filter and motorized timed plunger pump.

**Approved Lubricants** (The viscosity range is 150 to 8000 SUS at operating temperature.) The following lubricants or equivalents are approved for use in the automatic lubrication system. See Specification Sheet 1-137-0020 in this chapter.

| | |
|---|---|
| Gulf Oil Corp. and subsidiaries | Gulfway 52 |
| Mobil Oil Corp. | Mobil Vactra Oil No. 2 |
| Shell Oil Co. | Tonna 68 |
| Sun Oil Corp. | Sunoco Way Lubricant 1180 |
| Texaco Inc. | Way Lubricant D |

### 11.3.2 Maintenance and Service

**NOTE**

When starting a new machine, fill reservoir. It has a 1 quart (1 liter or 1000 cu cm) refill capacity. Pull and release the "Instant Feed" button at the top of the reservoir several times until the oil flows freely on all bearing surfaces.

**Maintenance**

1. Check the oil level daily and refill the reservoir when required.
2. Check the system periodically for loose or broken tubing, worn hoses, and loose fittings and connections.

3. Check the bearing surfaces daily. If there is too little oil, check the following and repair as necessary:
   a. Low oil level
   b. Broken, cracked tubing
   c. Loose connections
   d. Flattened lubricator outlet tube
   e. Clogged filter

**Motor Replacement**

1. Remove the motor cover and the two screens holding the motor to the top of the reservoir.
2. Replace the motor (Code No. 1-141-7850).
3. Upon reassembly, ensure the slot in the motor shaft is engaged with the pin in the drive shaft before replacing the screens.

For additional information on the lubrication system, see Parts Breakdown, Chapter 12.

# 11. Auxiliaries

## 11.3.2 Type TM-5 Lubricator Unit

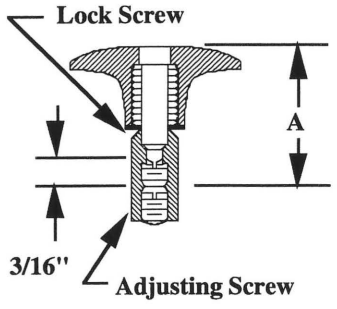
| VENDOR: BIJUR<br>No.: D-2994 | DESCRIPTION: LUBRICATOR UNIT TYPE TM-5 | Bridgeport<br>Code No.: 1-141-3208<br>Page 1 of 2 |
|---|---|---|

**When Ordering, Specify** Lubricator Type and Part Number such as: Lubricator Type TM-5 D-2994.

| LUBRICATOR CYCLE TIME IN MINUTES | | PART NUMBER WITH LIQUID LEVEL SWITCH |
|---|---|---|
| 50 Hz | 60 Hz | BIJUR |
| 6.4 | 5.3 | D-2994 |

**OPERATION** Lubricator is a motor-driven piston pump, spring-discharge type. Pump cycle time is controlled by an integral gear reduction in the motor. Lubricator can be actuated manually by raising and releasing the Instant Feed Button. Available cycle times are shown in the above table.

**DISCHARGE VOLUME PER CYCLE** Adjustable from 2.5 cc minimum to 5.0 cc maximum. The lubricator is supplied at the maximum stroke setting. To reduce oil delivery, remove the lockscrew; measure A, and turn adjusting screw clockwise, increasing dimension A in the increment (corresponding to the desired discharge), as shown on the following table.




| | INCH | DISCHARGE |
|---|---|---|
| * | 0.400 | 2.5cc |
| | 0.320 | 3.0cc |
| | 0.240 | 3.5cc |
| | 0.160 | 4.0cc |
| | 0.080 | 4.5cc |
| | 0 | 5.0cc |

* Factory set

**DISCHARGE PRESSURE** 60 psi maximum. Peak system pressure will decrease when: (a) discharge volume decreases; (b) number of Meter-Units in system increases; (c) oil viscosity decreases.

**OIL VISCOSITY RANGE** 150 to 8,000 SSU at operating temperature.

**LUBRICATOR FILTER** 40 micron particle separation. It should be inspected periodically and cleaned or replaced as required (Bijur S-109, Code No. 1-141-0078).

**DISTRIBUTION SYSTEM** Use Type F Meter Units (see Data Sheet 2400) limitations. The maximum number of meter units possible is 70. For system Flow Value (Øt) limitations, refer to the following table:

| Number of Meter-Units | CC's Per Cycle 2.5 | 3 | 4 | 5 | Max. Permissible System Flow Value, Øt |
|---|---|---|---|---|---|
| 5 | | 700 | 800 | 800 | |
| 10 | | 550 | 680 | 750 | |
| 15 | | 440 | 520 | 650 | |
| 20 | | 360 | 460 | 520 | |
| 25 | | 320 | 400 | 450 | |
| 30 | | 275 | 325 | 390 | |
| 40 | | 210 | 245 | 290 | |
| 50 | | 155 | 185 | 220 | |
| 60 | | 110 | 135 | 160 | |
| 70 | | 70 | 85 | 96 | |
| | Max. Permissible Flow Value | | | | |

**MOTOR** Continuous duty, single phase, synchronous induction timing motor for 50/60 Hz, dual wound for 115/230 volts ac. Power consumption: 3 watts. Code No. 1-141-7850.

For correct wiring, see instruction tag attached to lubricator.

Bijur reserves the right to change motor size, mounting dimensions, and/or manufacturer.

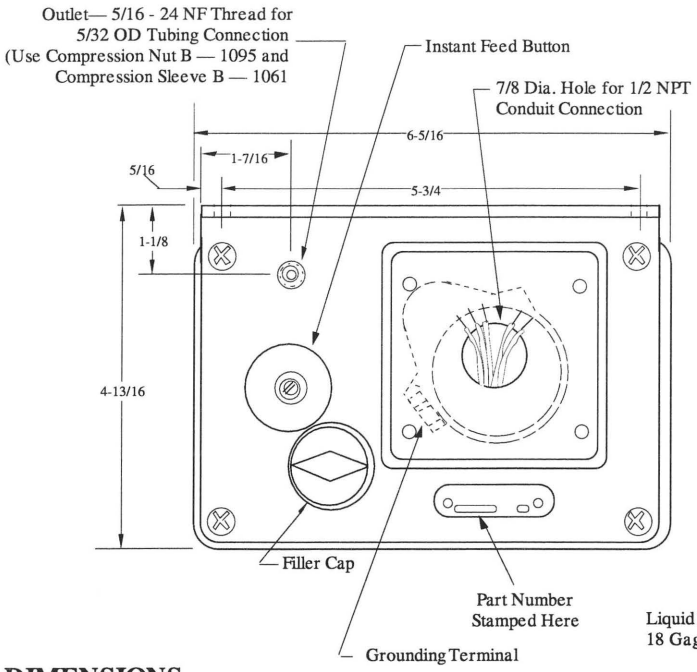
**LIQUID LEVEL SWITCH** The liquid level switch will close an electrical circuit whenever the oil in the reservoir is above the minimum operating level. Thus, when connected to a light or other indicating device, the liquid level can be monitored.

**Page 2 of 2**

Customers may reverse the operation when desired by inverting the float. When the float is reversed, the switch will close an electrical circuit whenever the oil level is below the minimum operating level.

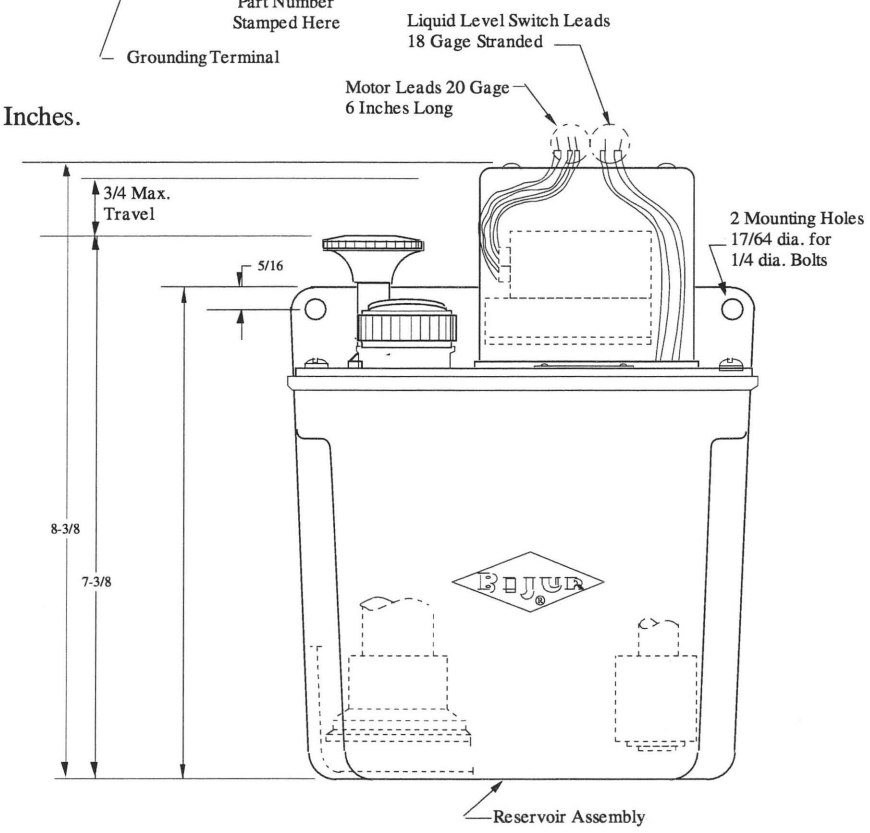
**NOTE**

Switch contact rating: 10 Watts maximum
(Light or indicating device not supplied by Bijur).




**DIMENSIONS**

All dimensions are in Inches.



# LUBE SPECIFICATION
# NO. 1-037-0001

**GENERAL DESCRIPTION:** Hydraulic Oil — High quality nondetergent mineral oil with metallic phosphate antiwear additive.

**USES:** Hydraulic systems, spindles, turbines, gear drives, sleeves or roller bearings, and Kusters Swimming Rolls (non-driven).

Lubricant specifications listed here are minimum standards which must be met by all lubricants recommended for use on the machine. For specific applications to the machines, see lubrication recommendation sheets for individual machines.

| **LUBE CODE NO. 1-037-0001** | | | **1-037-0002** |
|---|---|---|---|
| ASTM or ASLE Lube No. | | | 150 |
| Viscosity S.U.S. | | 100 °F | 135/165 |
| | | 210 °F | — |
| V.I. — Min. | | | 95 |
| Flash Point — °F Min. | | 400 | |
| Pour Pt. — °F Max. | | | 10 |
| Max. Op. Temp. — °F | | ⑦ | 200 |
| Additives or Inhibitors | | ⑧ | R.O.W.F. |
| TEST REQUIREMENTS | | | |
| Timkin O.K. Ld. — Min. | | | — |
| Oxidation | ASTM D-943 | Min. Hrs. | 1500 |
| | | Neut. No. Chg. | 0.25 |
| | ASTM D-943 Modified | | — |
| Cu. Corrosion — ASTM D-130 STAIN | | | #1 |
| ASLE Accelerated Breakdown Test | | | — |
| Foam — ASTM — D-892 | | | ② |
| Emulsion — ASTM — D-1401 | | | ③ |
| Bijur Differential Filtration Test | | | — |
| Evaporation Rockwell Test | | | ⑥ |
| Stick Slip Ratio — CMM Test — Max. | | | — |
| Rust — ASTM D-665A | | | PASS |

# LUBE SPECIFICATION
# NO. 1-037-0020

**GENERAL DESCRIPTION:** Waylube — Must contain tackiness additives; must NOT contain lead or chlorine compound additives.

**USES:** Machine tool way, heavy loaded journals, and screws.

Lubricant specifications listed here are minimum standards which must be met by all lubricants recommended for use on the machine. For specific applications to the machines, see lubrication recommendation sheets for individual machines.

| **LUBE CODE NO. 1-037-0020** | | | **1-037-0021** |
|---|---|---|---|
| | | | Waylube |
| ASTM or ASLE Lube No. | | | 315 |
| Viscosity S.U.S. | 100 °F | | 283/347 |
| | 210 °F | | — |
| V.I. — Min. | | | — |
| Flash Point — °F Min. | | | 350 |
| Pour Pt. — °F Max. | | | 0 |
| Max. Op. Temp. — °F | | | 150 |
| Additives or Inhibitors ⑧ | | | R.F.S. |
| TEST REQUIREMENTS | | | |
| Timkin O.K. Ld. — Min. | | | — |
| Oxidation | ASTM D-943 | Min. Hrs. | — |
| | | Neut. No. Chg. | — |
| | ASTM D-943 Modified | | — |
| Cu. Corrosion — ASTM D-130 STAIN | | | — |
| ASLE Accelerated Breakdown Test | | | ⑤ |
| Foam — ASTM — D-892 | | | ② |
| Emulsion — ASTM — D-1401 | | | — |
| Bijur Differential Filtration Test | | | PASS |
| Evaporation Rockwell Test | | | ⑥ |
| Stick Slip Ratio — CMM Test — Max. | | | 0.85 |
| Rust — ASTM D-665A | | | PASS |

# 11. Auxiliaries

## 11.4 PRESSURE REGULATOR

| VENDOR: C.A. NORGREN CO<br>No.: F12-200-A3TA | DESCRIPTION:<br>COMPRESSED AIR FILTER | Bridgeport<br>Code No.: 1-101-0311<br>Page 1 of 1 |
|---|---|---|

**SPECIFICATIONS**

**Filter Element (Sintered Bronze)**

50-Micron (Standard)
5 or 25-Micron (Optional)

**Bowl**

1/2 pt. Transparent Polycarbonate (Standard)
1/2 pt. Aluminum (Optional)

**Maximum Rated Operating Conditions**

**Polycarbonate Bowl**

150 psi (10.3 bar)
125° F (52° C)

**Metal Bowl**

250 psi (17.2 bar)
175° F (80° C)

**GRAPHIC SYMBOLS**

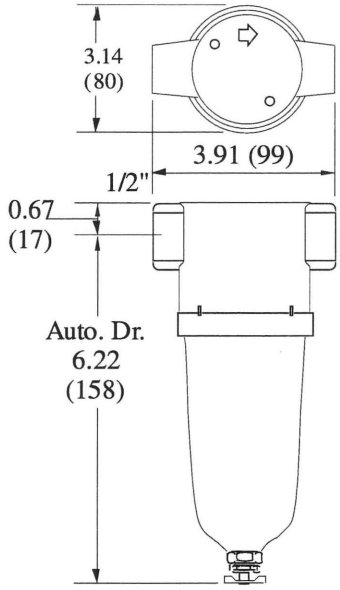
Manual Automatic

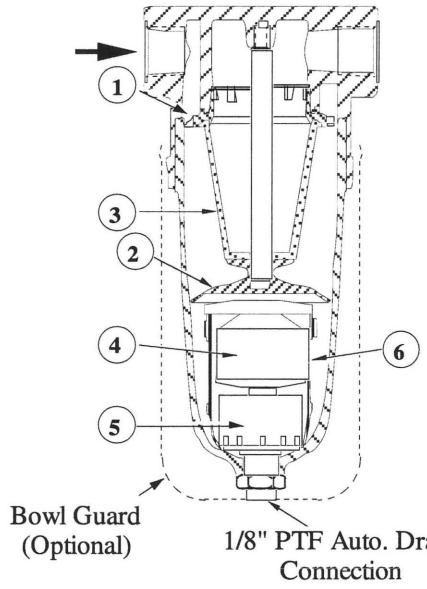
Air entering the filter is guided into a swirling pattern by the louvers (1). Liquid and coarse particles are thrown against the bowl wall by centrifugal force and run down to the bottom of the bowl. Baffle (2) creates a "quiet zone" at the bottom of the bowl to prevent air turbulence from re-entraining separated liquid into the air stream. Air leaving the bowl passes through the element (3) where finer solid particles are removed and retained.

The automatic drain (4 and 5) is a float-operated mechanism at the bottom of the bowl which automatically expels any liquid which accumulates above a certain level. An over-accumulation of liquid in the bottom of the bowl causes float (4) to rise. This admits bowl pressure into the drain mechanism (5), opening a bleed valve and allowing excess liquid to be expelled under pressure. When the liquid level drops sufficiently, the float drops and draining stops. A screen (6) around the drain mechanism traps large particles which would not pass through the bleed valve. The automatic drain is normally open during shutdown periods so that any liquid in the bowl or which may later collect drains by gravity and does not overfill the bowl. At startup, the automatic drain will close when bowl pressure reaches approximately 5 psi. Minimum operating pressure is 10 psi.

**DIMENSIONS**

All dimensions are in inches (millimeters).



## 11.5 PRESSURE REGULATOR

| VENDOR<br>C.A. NORGREN CO<br><br>No.: R07-200RGKA | DESCRIPTION<br>PRESSURE REGULATOR<br>TYPE R07 FOR COMPRESSED<br>AIR SERVICE | Bridgeport<br>Code No.: 1-101-0264<br>Page 1 of 2 |
|---|---|---|

**SPECIFICATIONS**

**Fluid:** Compressed Air

**Main Ports:** 1/8 or 1/4 in. PTF

**Gauge Ports:** Two 1/8 in. PTF full flow

**Rated Operating Conditions**

**Inlet Pressure:** 400 psi (27.6 bar) maximum
**Temperature:** 0° to 150° F (-18° to 66° C) with dew point less than air temperature below 35° F (2° C)

**Type:** Diaphragm; relieving or non-relieving

**Outlet Pressure Adjustment Ranges*** —

Standard: 3 to 100 psi (0.2 to 6.9 bar)
Optional: 2 to 50 psi (0.1 to 3.4 bar)
Optional: 1 to 10 psi (0.07 to 0.7 bar)

* Outlet pressure adjustment ranges are not minimum or maximum outlet pressure limits. Regulators can be adjusted to zero psi outlet pressure and, generally, to pressure in excess of those specified. The use of these regulators to control pressures outside of the specified ranges is not recommended.

**Materials of Construction**

| | |
|---|---|
| Bonnet | Acetal Resin |
| Body | Die Cast Zinc |
| Valve | Brass |
| Valve Seat | Acetal Resin |
| Elastomers | Buna-N |

**OPERATION**

A regulator is used in a compressed air system to maintain a nearly constant outlet pressure despite changes in the inlet air pressure and changes in downstream flow requirements.

Outlet pressure is controlled by an adjusting knob. Clockwise rotation increases and counterclockwise rotation decreases outlet pressure.

**Relieving-Type Regulators.** With relieving regulators, outlet pressure can be reduced even though the system is dead-ended.

The regulator will likewise relieve in response to an increase in outlet pressure above the regulator setting, allowing air to escape to atmosphere. However, the flow capacity of the relief passage is limited; and depending upon the source of the overpressure condition, the outlet pressure might increase to a point significantly higher than the regulator setting. For this reason, the relief feature of a regulator must not be relied upon as an overpressure safety device. See the following WARNING note.

**CAUTION**

These regulators are intended for use in industrial compressed air systems only. Do not use these regulators where pressure or temperature can exceed rated operating conditions. See Specifications.

If outlet pressures in excess of the regulator pressure setting could cause downstream equipment to rupture or malfunction, install a pressure relief device downstream of the regulator. The relief pressure and flow capacity of the relief device must satisfy system requirements.

Before using fluids other than air, for non-industrial applications, or for life support systems, consult C.A. Norgren Co. for approval.

Non-relieving Type Regulators With non-relieving regulators, outlet pressure can not be reduced if the system is dead-ended. This type of regulator will not vent the outlet air pressure as described under "Relieving Type Regulators" and some other means of venting the outlet air pressure must be provided.

**INSTALLATION**

1. Install regulator as close as possible to the device serviced. The "IN" port is marked on the regulator body. Regulator can be installed at any angle.

2. In systems with a cyclic demand, install regulator upstream of cycling control valves.
3. Air line piping should be same size as regulator ports.
4. Connect piping to proper ports using pipe thread sealant on male threads only. Do not allow sealant to enter interior of body.
5. Connect outlet pressure gauge (if used) to one of the gauge ports on side of body. Gauge ports can also be used as additional low flow outlets. Plug unused ports.
6. To obtain maximum reliability and service life, install a filter upstream of the regulator.

**ADJUSTMENT**

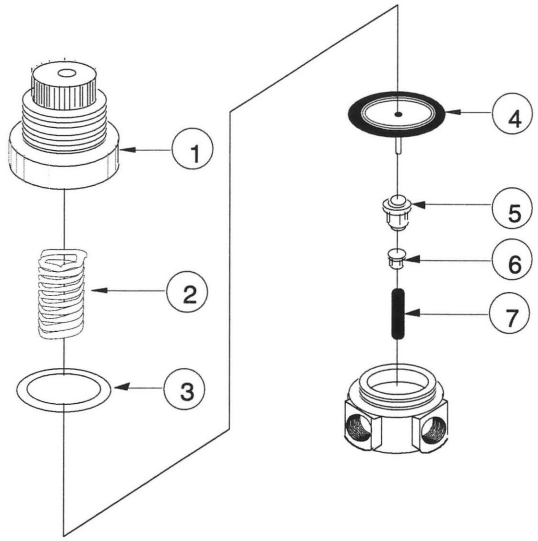
1. Before turing on system air pressure, turn regulator adjustment fully counterclockwise.
2. Turn on system air pressure.
3. Turn on regulator adjustment clockwise until the desired outlet pressure is reached.
4. To avoid minor readjustment after making a change in pressure setting, always approach the desired pressure from a lower pressure. When reducing from a higher to a lower setting, first reduce to some pressure less than that desired, then bring up to the desired point.
5. Push lockring on adjusting knob downward to lock pressure setting. To release, pull lockring upward.

**MAINTENANCE**

1. Shut off inlet pressure and reduce pressure to zero in inlet and outlet lines.
2. Turn adjusting knob fully counterclockwise. Regulator can be disassembled without removal from air line.
3. Unscrew the bonnet (1), then remove regulating spring (2), slipring (3), and diaphragm (4). Unscrew the valve seat (5) using a 3/8 inch socket, then remove valve (6) and valve spring (7).
4. Clean parts using warm water and soap.
5. Inspect all parts.
6. Replace damaged parts.
7. At reassembly, apply a small, even amount of Lubriplate 110 (or equivalent) to adjusting screw threads inside bonnet (1).
8. Torque valve seat (5) to 7-10 inch-pounds. Torque bonnet (1) to 50-60 inch-pounds.

**REPAIR KITS**

| | |
|---|---|
| Non-relieving Regulators | |
| (Items 3 through 7) | 3407-01 |
| Relieving Regulators | |
| (Items 3 through 7) | 3407-02 |



## 11.6 MINIATURE MICRO-FOG LUBRICATOR

| VENDOR<br>C.A. NORGREN CO<br><br>No.: L07-200MPAA | DESCRIPTION<br>MINIATURE MICRO-FOG LUBRICATOR FOR COMPRESSED AIR SERVICE | Bridgeport<br>Code No.: 1-101-0263<br>Page 1 of 4 |
|---|---|---|

**SPECIFICATIONS**

**Port Threads**: 1/8" or 1/4" PTF

**Oil Reservoirs**

Standard: Transparent Polycarbonate; 1/2 oz. (0.015 liter) oil capacity

Optional: Metal; 1/2 oz. (0.015 liter) oil capacity

**Maximum Rated Operating Conditions**

Polycarbonate Reservoir: 150 psi (10.3 bar); 125° F (52° C)

Metal Reservoir: 250 psi (17.2 bar); 75°F (79°C)

**Recommended Operating Flow Range**

0.5 to 10 scfm (0.25 to 4.7 dm3/s) at 90 psi (6.2 bar)

**Recommended Lubricants:** This lubricator will perform satisfactorily using misting-type oils rated 50 to 200 SSU at 100° F (38° C). The oils used must be compatible with materials of construction. Contact your lubricant supplier and the builder of the equipment to be lubricated to obtain specific lubricant recommendations.

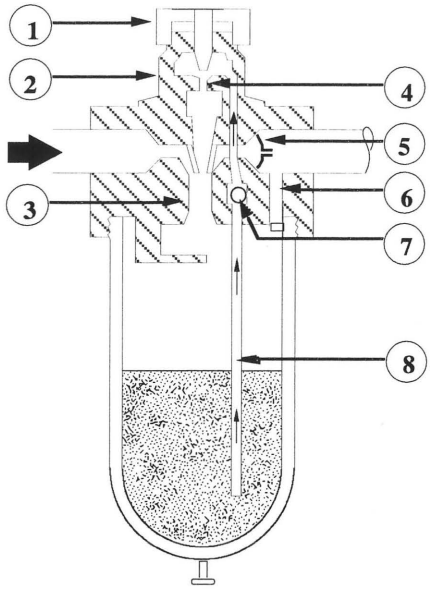
**Materials of Construction**

Body.....Zinc
Reservoir
Transparent.....Polycarbonate
Metal.....Aluminum
Sight Feed Dome.....Trogamid-T
Elastomers.....Neoprene and Buna-N

**OPERATION**

The Micro-Fog lubricator is a device for injecting a finely divided 'fog' of oil into a flowing stream of compressed air to automatically provide the proper internal lubrication for air-operated tools and other devices. Micro-fog density is controlled by the drip rate adjusting knob (1). Counterclockwise rotation increases and clockwise rotation decreases Micro-Fog density.

The lubricator utilizes a flexible flow sensor (5) to control the flow of a small amount of inlet air into the reservoir through the fog generator (3) in proportion to the air flow past the sensor. The high velocity air flowing through the generator aspirates oil up the siphon




tube (8) into the sight-feed dome (2), where it drips downward through the generator into the reservoir. Most of the larger oil particles return to the reservoir. The finer particles (MicroFog) remain airborne and are carried through passage (6) into the downstream system. Only a small portion of the drops visible in the sight-feed dome are delivered downstream to the device being lubricated. The proportionate control afforded by the flow sensor provides a nearly constant oil-to-air density ratio over a wide range of air flows. Check ball (7) keeps the siphon tube full during periods of low flow.

**WARNING**

These units are intended for use in industrial compressed air systems only. They must not be used where pressure or temperature may exceed maximum operating conditions. See Specifications.

The polycarbonate plastic reservoirs used in these units can be damaged and possibly burst if exposed to such substances as certain solvents, strong alkalies, compressor oils containing ester-

based additives, or synthetic oils. Fumes of these substances in contact with the polycarbonate reservoir, externally or internally, can also result in damage. Clean with warm water only.

Use metal reservoir in applications where a plastic reservoir might be exposed to substances that are incompatible with polycarbonate.

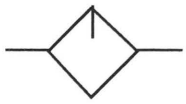
In lubrication applications, some oil mist may escape from the point of use into the surrounding atmosphere. Users are referred to OSHA Safety and Health Standards for limiting oil mist contamination and utilization of protecting equipment.

Before using with fluids other than air, for non-industrial applications, or for life support systems, consult C.A. Norgren Co.

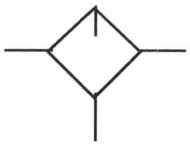
**INSTALLATION**

1. Air line piping should be the same size as lubricator ports.
2. Install lubricator vertically (adjustment knob up) in air line downstream of filter and regulator as near as possible to the device being served.
3. Connect piping to proper ports using pipe thread sealant on male threads only. Do not allow sealant to enter interior of lubricator. Air flow must be in direction of arrow on top of body.
4. Fill reservoir with a good quality lubricant (see Specifications) to level indicated by maximum fill line. **DO NOT OVERFILL.**

**GRAPHIC SYMBOLS**



No Drain

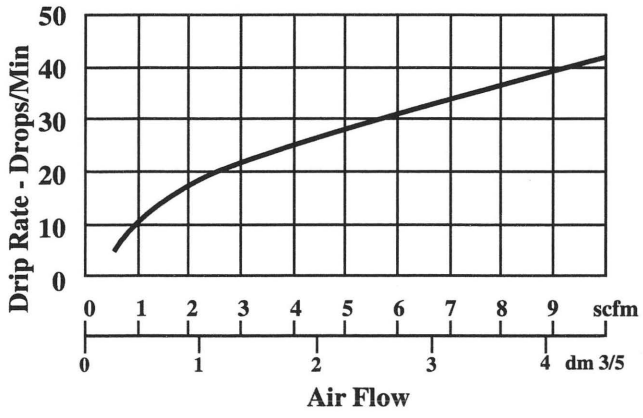


Manual Drain

**ADJUSTMENT**

1. Turn lubricator drip rate adjusting knob fully clockwise, then turn on system air pressure.
2. Adjust lubricator drip rate only when there is a constant rate of air flow through the lubricator. Monitor drip rate through sight feed dome.
3. Determine the average rate of air flow (scfm) through the lubricator, then turn the adjusting knob to obtain the recommended drip rate (Drops/Min). Turn adjusting knob counterclockwise to increase and clockwise to decrease the drip rate. Push lockring on adjusting knob downward to lock drip rate setting. To release, pull lockring upward.
4. Monitor the device being lubricated for a few days following initial adjustment. Readjust the drip rate if the oil delivery at the device appears either excessive or low.
5. Drip rate setting can be made tamper resistant by installing a seal wire (see Accessories) in groove above lockring.

**Table 11-1.** Recommended Drip Rate Setting for Average Lubrication



**DISASSEMBLY**

1. Shut off pressure and reduce pressure in the inlet and outlet lines to zero. Loosen fill plug (1). Lubricator can be disassembled without removal from air line.
2. Use a 1-inch deep socket to remove the sight feed dome (3), then remove seal (4), oil fill plug (1), O-ring (2), reservoir (7), O-ring (8), and baffle (6). Do not attempt to remove siphon tube (10) from body (5), as these parts are permanently assembled.

**CLEANING**

1. Clean transparent reservoir (7) using warm water. Clean other parts using soap and water. Dry parts and blow out internal passages in body (5) using clean, dry compressed air.
2. Inspect all parts carefully.
3. Replace damaged parts. If plastic reservoir shows signs of cracking or cloudiness, replace with metal reservoir.

**REASSEMBLY**

1. Prior to reassembly, apply a generous coat of Dow Corning 44 grease (or equivalent) to seal (4) and O-rings (2,8). Apply a small amount of Dow Corning Molykote G grease (or equivalent to full length of threads on metal reservoirs.
2. Torque sight-feed dome (3) to 30-35 inch-pounds. Torque reservoir to 5-10 inch-pounds.

**REPAIR KITS**

| | |
|---|---|
| Seal Kit (Items 2,4,8) | 3795-03 |

**REPAIR PARTS**

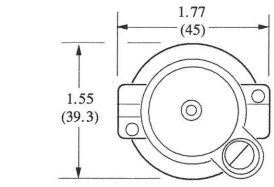
| | |
|---|---|
| Metal Reservoir (with drain, Items 7 & 9) | 3809-52 |
| Polycarbonate Reservoir (without drain, Item 7) | 3635-64 |
| Polycarbonate Reservoir (with Drain, Items 7 & 9) | 3635-63 |
| Sight-Feed Dome (Item 3) | 5055-54 |

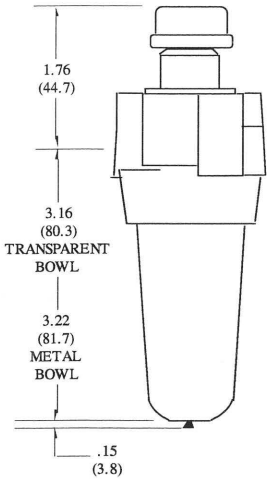
**ACCESSORIES**

| | |
|---|---|
| Mounting Bracket and Screws | 5939-08 |
| Tamper Resistant Seal Wire | 2117-01 |

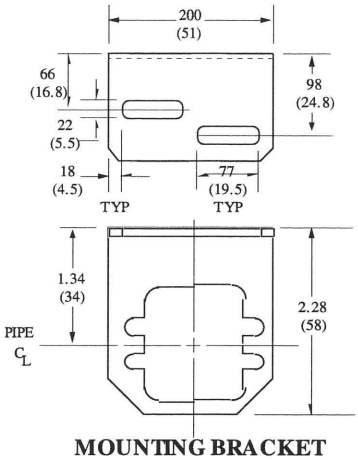
## DIMENSIONS

All dimensions are in inches (mm).

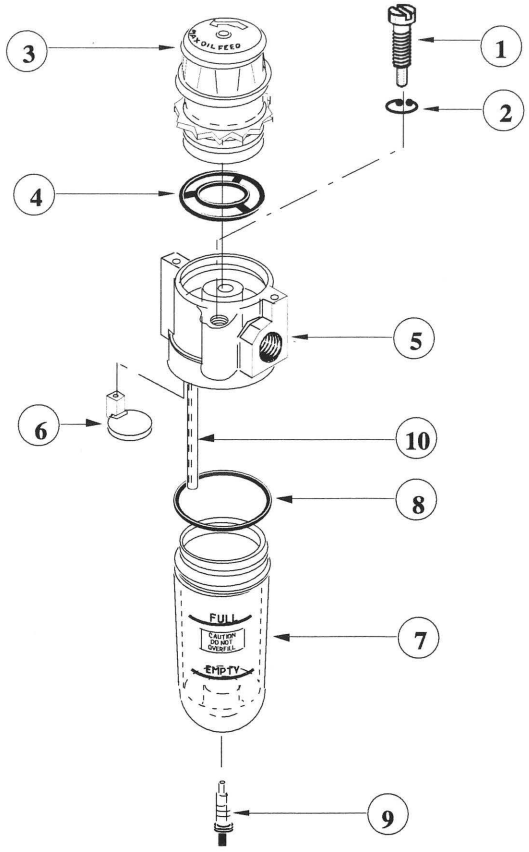



**LUBRICATOR**

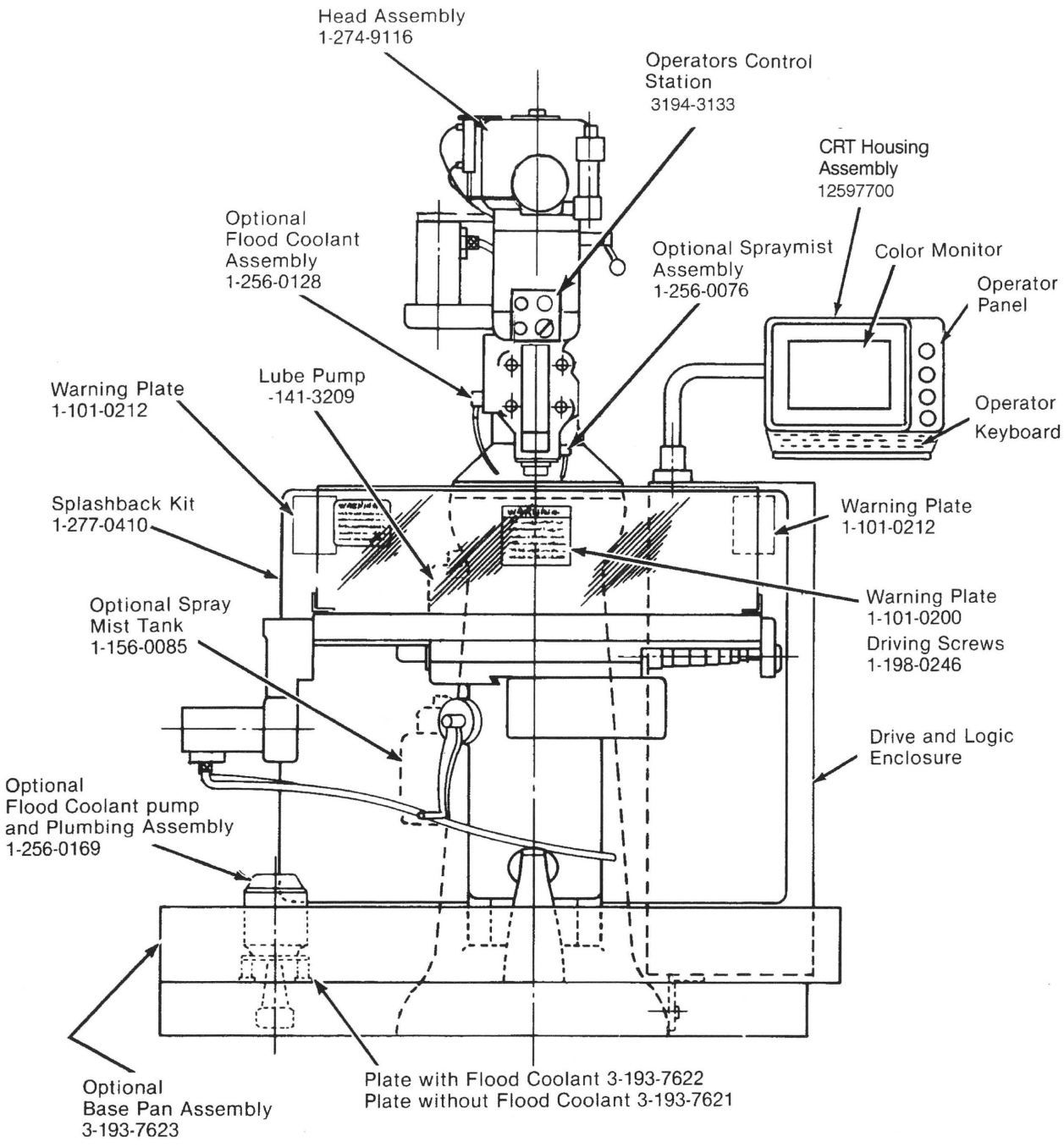



**MOUNTING BRACKET**

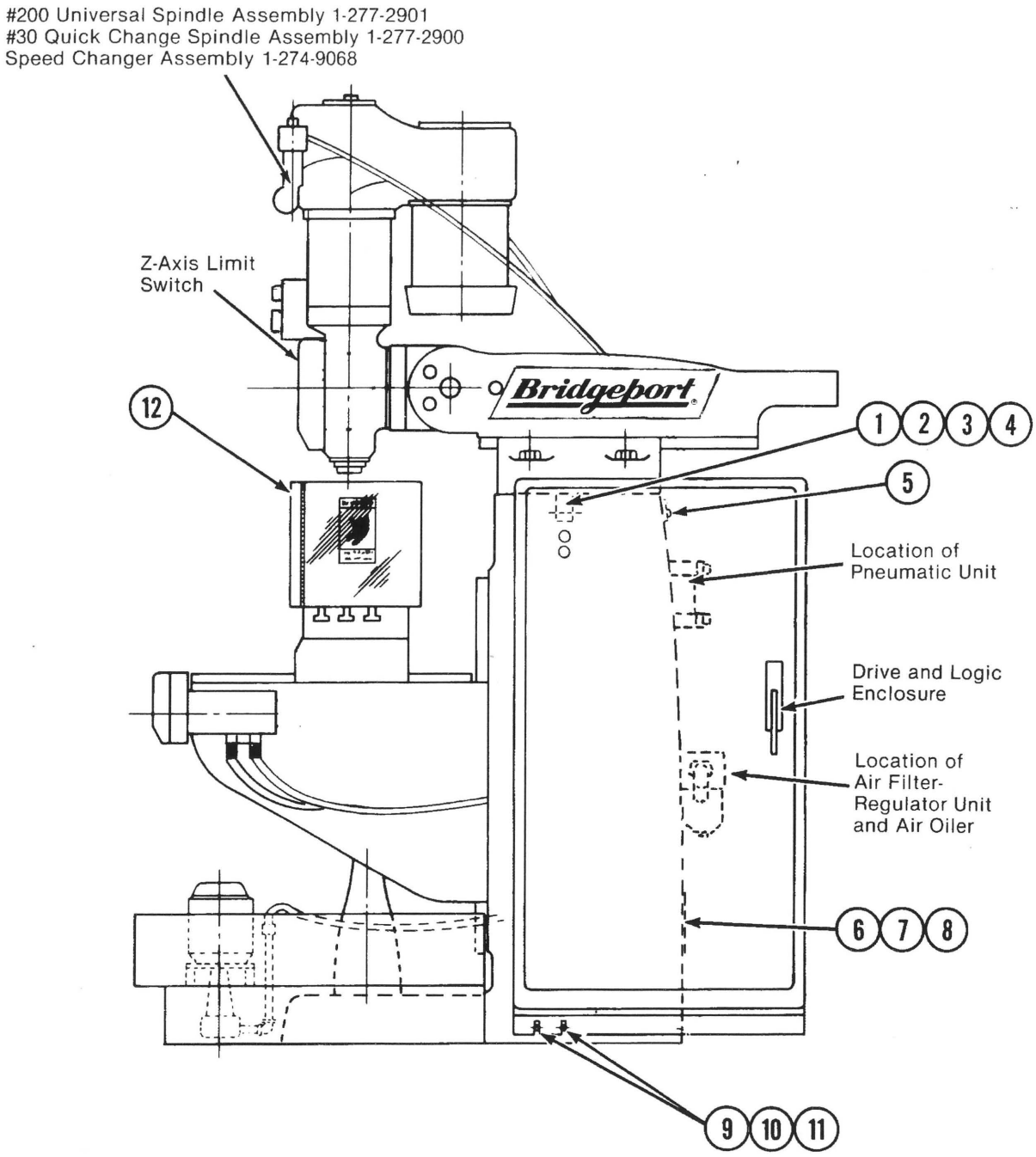


# CHAPTER 12. Parts Breakdown

## MACHINE ASSEMBLY — FRONT VIEW



## MACHINE ASSEMBLY — SIDE VIEW



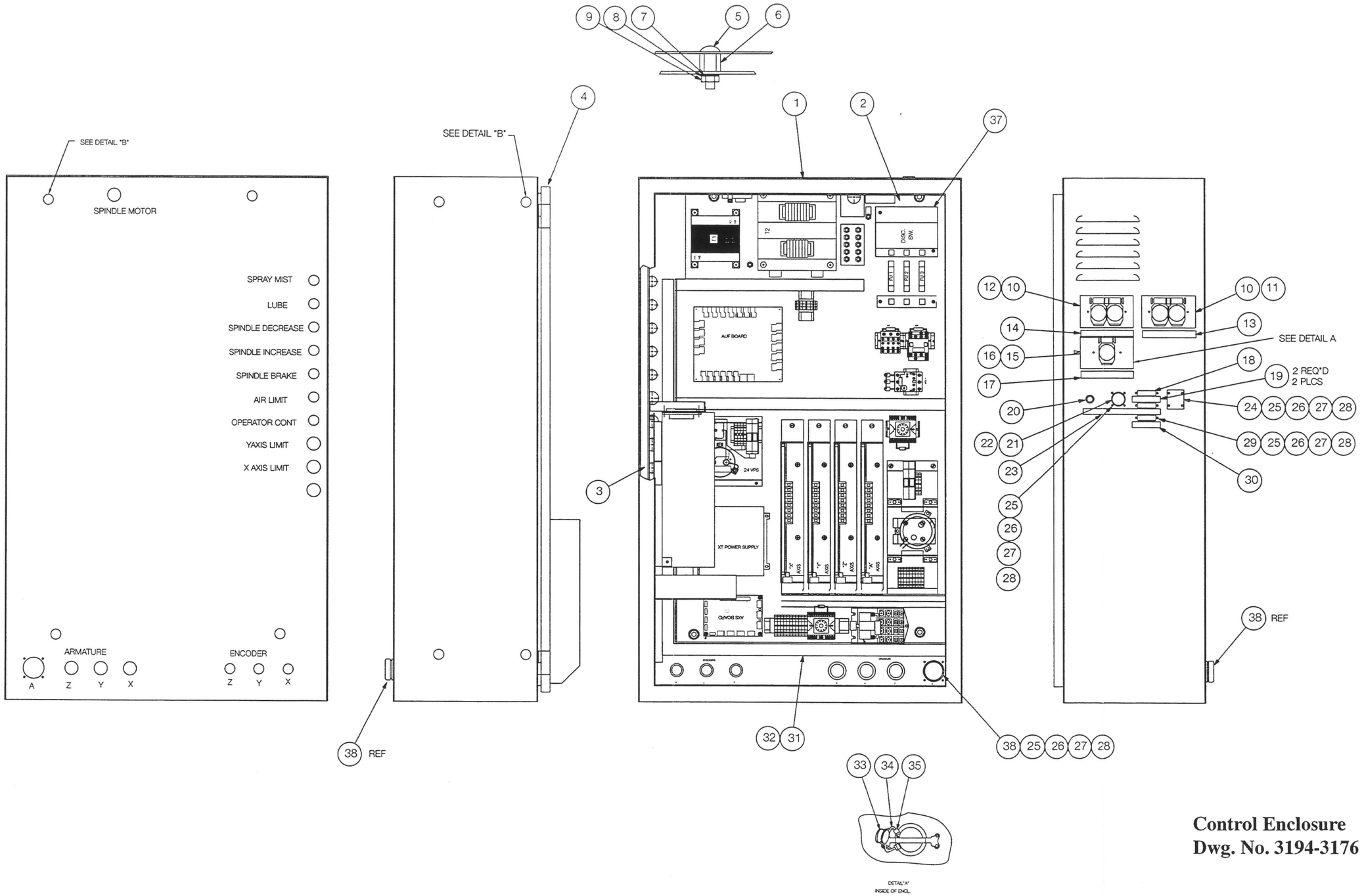
## MACHINE ASSEMBLY — SIDE VIEW

| Item | Code No. | Description |
|---|---|---|
| 1 | 1-101-1138 | H.H.C.S., 0.250-20 x 0.750 (2) |
| 2 | 1-101-1707 | Hex Nut, 0.25-20 (2) |
| 3 | 1-111-1912 | Flat Washer, 0.250 (4) |
| 4 | 3-192-7820 | Bracket Assembly |
| 5 | 1-101-1033 | S.H.C.S., 0.25-20 x 0.750 (2) |
| 6 | 1-104-0019 | Patent Plate |
| 7 | 1-198-0426 | Drive Screw |
| 8 | 1-106-2834 | Bpt. Name Plate |
| 9 | 1-101-1073 | S.H.C.S., 0.375-16 x 0.750 (4) |
| 10 | 1-115-1913 | Flat Washer, 0.375 (4) |
| 11 | 1-119-1922 | Lock Washer, 0.375 (4) |
| 12 | 1-174-9036 | Chip and Coolant Shield Assembly |

## CONTROL ENCLOSURE ASSEMBLY — Dwg. No. 3194-3176

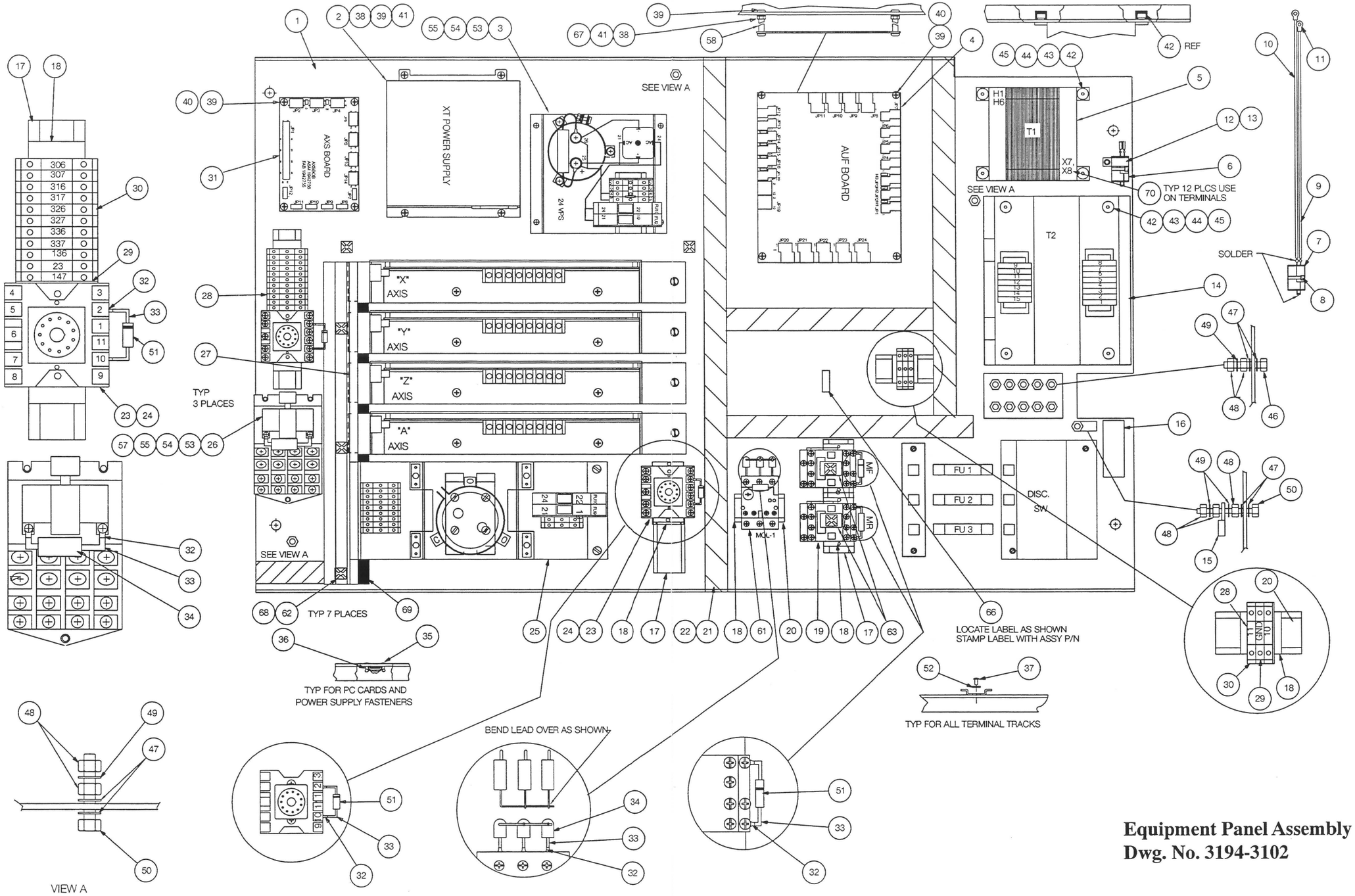
| Item | Code No. | Description |
|---|---|---|
| 1 | 31943143 | Weld Control Enclosure (1) |
| 2 | 31943102 | Equipment Panel Assy. (1) |
| 3 | 31943118 | Computer Panel Assy (1) |
| 4 | 31943186 | Door Assy (1) |
| 5 | 31508600 | Bolt, Crg, Sq. Neck But Hd (8) |
| 6 | 31508599 | Spacer, Hex Tapped 3/8-16 (8) |
| 7 | 11151913 | Washer, 3/8x.81x.06 Flat (8) |
| 8 | 31506594 | Washer, .375" Spring Lock (8) |
| 9 | 31506540 | Nut >375-16 Plain Hex (8) |
| 10 | 31503332 | Cover, Receptacle Duplex (2) |
| 11 | 31503733 | Conn, Receptacle 2 Pole (1) |
| 12 | 31503767 | Recep, Duplex 125v, 15a (1) |
| 13 | 31936827 | Plate, ID Misc Funct .300 (1) |
| 14 | 31939599 | Label, Duplex Worklight (1) |
| 15 | 31507297 | Receptacle Single 2 Pole (1) |
| 16 | 31507298 | Plate Covers, Recep (1) |
| 17 | 319265358 | Plate, Wrn, Coolant Only (1) |
| 18 | 31540217 | Connector, El. Jack Socket (4) |
| 19 | 31941290 | Label LPT1 (1) |
| 20 | 31943724 | Reset Cable (1) |
| 21 | 31505104 | Gasket, Plain (1) |
| 22 | 31506080 | Cap, Mch Plug 1 1/8Thd (1) |
| 23 | 31938695 | Label Switch & Receptacle (1) |
| 24 | 31942601 | Blanking Plate Network (1) |
| 25 | 31506402 | Scr PHP #4-40x1/2 (14) |
| 26 | 31506556 | Washer, Flat #4 (14) |
| 27 | 31506588 | Washer, Splt #4 (14) |
| 28 | 31506533 | Nut, Plain Hex (14) |
| 29 | 31941291 | Plate, Cover (1) |
| 32 | 31541773 | Cover, Wireway 1"W x 6' lg (.79) |
| 33 | 31508981 | Varistor, Metal Oxide (2) |
| 34 | 31541747 | Tubing, Ht Shrink 1/16" ID (.50) |
| 35 | 31500533 | Term-Spade Lug 22/16 awg (2) |
| 36 | 31943177 | Cable Set (1) |
| 37 | 31542045 | Disconnect Assy. (1) |
| 38 | 31505083 | Metal Cap (1) |
| 39 | 31942363 | Sleeve Assembly (1) |
| 40 | 11011052 | SHCS, .312-18x.750: lg (2) |
| 41 | 31542450 | Plug Button (7/8 dia hole) (2) |

# 12. Parts Breakdown




**Control Enclosure**
**Dwg. No. 3194-3176**

# 12. Parts Breakdown




**Equipment Panel Assembly**
**Dwg. No. 3194-3102**

## EQUIPMENT PANEL ASSEMBLY — Dwg. No. 3194-3102

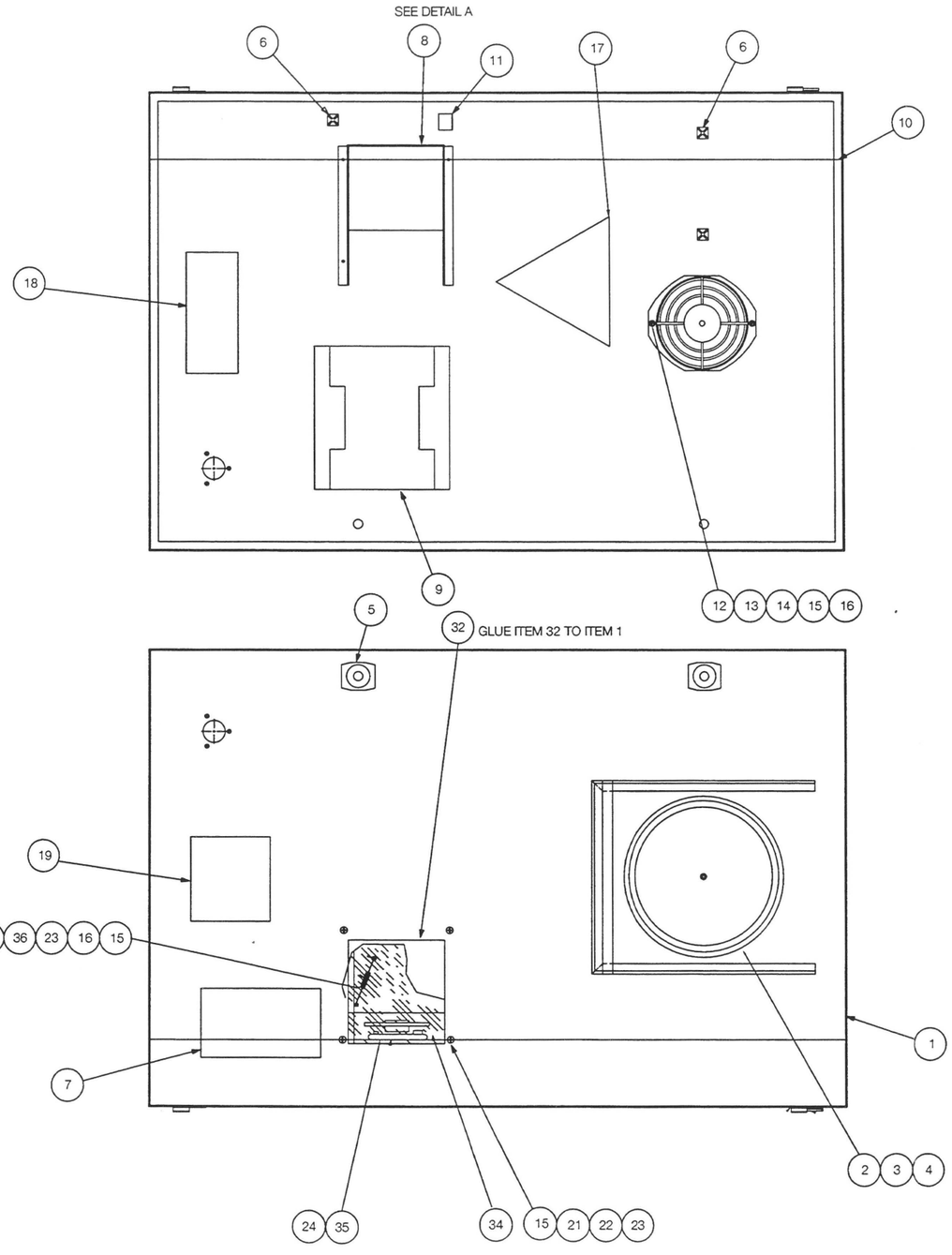
| Item | Code No. | Description |
|---|---|---|
| 1 | 31943074 | Detail, Equipment Panel |
| 2 | 31942930 | Power Supply Logic Assy |
| 3 | 31943117 | 100v Power Supply Assy (1) |
| 4 | 31942616 | AUF Final Assembly |
| 5 | 31541865 | XFMR, 500va, Pwr, 50/60hz (1) |
| 6 | 31540960 | MTLZ, Polyest Directric (1) |
| 7 | 31502030 | Pwr, Res, PW 5A, 200 Ohms (1) |
| 8 | 31500585 | Cable Tie 8" (1) |
| 9 | 31505187 | Wire, Wht 18 awg (1) |
| 11 | 31500531 | Term-Ring, PIDG 22/16 #10 (2) |
| 12 | 31501208 | Clamp, Wire (1) |
| 13 | 31509090 | Scr, Thd Form 8-32x5/8 lg (1) |
| 14 | 31542606 | Transformer, Power (1) |
| 15 | 31541032 | Term, Ground Lug #10 (1) |
| 16 | 31937508 | Label, Dedicated Gnd Lug (1) |
| 17 | 31942370 | Mounting Rail 35mmx5.06 (2) |
| 18 | 31508131 | Terminal Block End Clamp (10) |
| 19 | 31542641 | Contactor Reversing (1) |
| 20 | 31942868 | Mtg Track Din Rail 35mm (2) |
| 21 | 31541393 | Wireway, PVC 1x2 (.92) |
| 22 | 31541773 | Cover, Wireway 1"w x 6' lg (.92) |
| 23 | 31542223 | Relay Sockets 11 pin (2) |
| 24 | 31503497 | Relay 10 amp, 3 PDT (2) |
| 25 | 31943109 | 24v Power Supply Assy (1) |
| 26 | 31541772 | Relay, AC Control 10a (1) |
| 27 | 31943163 | Driver Module Assembly (3) |
| 28 | 31508130 | Term Block, M4/6, 10-22awg (14) |
| 29 | 31508438 | Terminal Block End Plate (2) |
| 30 | 31508911 | Tag, Dekafix, 10 tags 10 rows (28) |
| 31 | 31942756 | PC Board AXSBOB Assy |
| 32 | 31502954 | Lug, Slotted Ring Tongue (13) |
| 33 | 31506447 | Sleeving Insul Elec 20 awg (1) |
| 34 | 31504677 | Arc Suppressor |
| 35 | 31500245 | Pop Rivet (12) |
| 36 | 31504981 | Recep, Steel Leaf Spg (6) |
| 37 | 31503675 | Pop Rivets, SP-34-BS Fstnr (10) |
| 38 | 31506557 | Washer, Flt #6 5/16" OD (8) |
| 39 | 31506410 | Scr, PHP #6-32x1/2 (16) |
| 40 | 31506579 | Washer, Lk IT #6 (12) |
| 41 | 31506589 | Washer, Lk Splt #6 (4) |
| 42 | 31503392 | Nut, Speed Grip 1/4-20 (8) |
| 43 | 31506592 | Washer, Lk Splt 1/4 (8) |
| 44 | 31506560 | Washer, Flt, 1/4" (8) |
| 45 | 11011033 | SHC, .250-20x .750" lg (8) |
| 46 | 31506442 | Scr, PHP #10-32x5/8 (10) |
| 47 | 31506575 | Washer, Lk ET #10 (28) |
| 48 | 31506547 | Nut, Plain Hex (28) |
| 49 | 31506581 | Washer, Lk IT #10 (14) |
| 50 | 31508047 | Scr, Thd Form 10-32x1-1/4 (4) |
| 51 | 31500029 | Diode, Silicon (4) |
| 52 | 31506558 | Wsh, Flat Plain (10) |
| 53 | 31506441 | Scr, Mach PHP #10-32x1/2"lg (7) |
| 54 | 31506559 | Washer, Flat #10 (7) |
| 55 | 31506591 | Washer, Spr #10 (7) |
| 57 | 31918155 | AC Mag Relay Pole Assy (1) |
| 58 | 31542629 | Standoff 6-32 x 1 1/4 (4) |
| 59 | 31943211 | AC Harness Assy (1) |
| 60 | 31943209 | DC Harness Assy (1) |
| 61 | 31542222 | Motor Overload Mount (1) |
| 62 | 31541074 | Pad, Cable Tie (7) |
| 63 | 31542720 | Contact Block (2) |
| 64 | 31943433 | Cable Internal A Axis (1) |
| 65 | 31942924 | Terminal Track 7.5 lg (1) |
| 66 | 31542725 | Label DAT-18-502-10 (1) |
| 67 | 31506535 | Nut, Hex #6-32 (4) |
| 68 | 31500585 | Tie, Cable 8" (7) |
| 69 | 31502328 | Neoprene Adh Back (1.20) |
| 70 | 31506580 | Washer, Lock Type A No. 8 (12) |
| 71 | 31943726 | Hour Meter Assembly (1) |
| 72 | 31943210 | DC Contactor Harness Assy (1) |

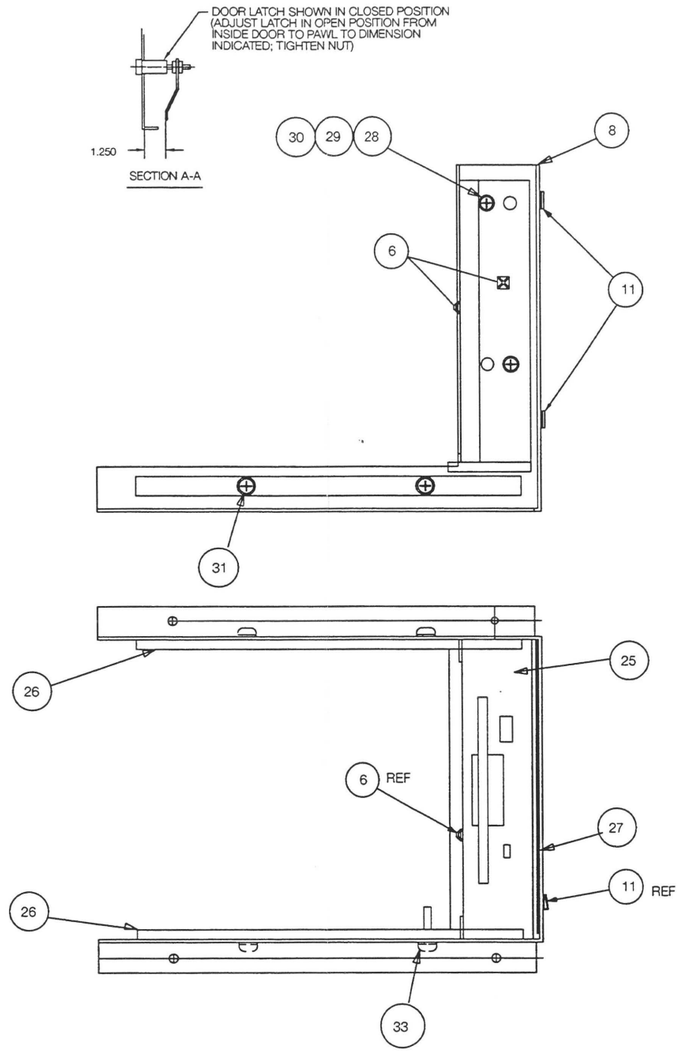
# 12. Parts Breakdown

## DOOR ASSEMBLY – Dwg. No. 3194-3186

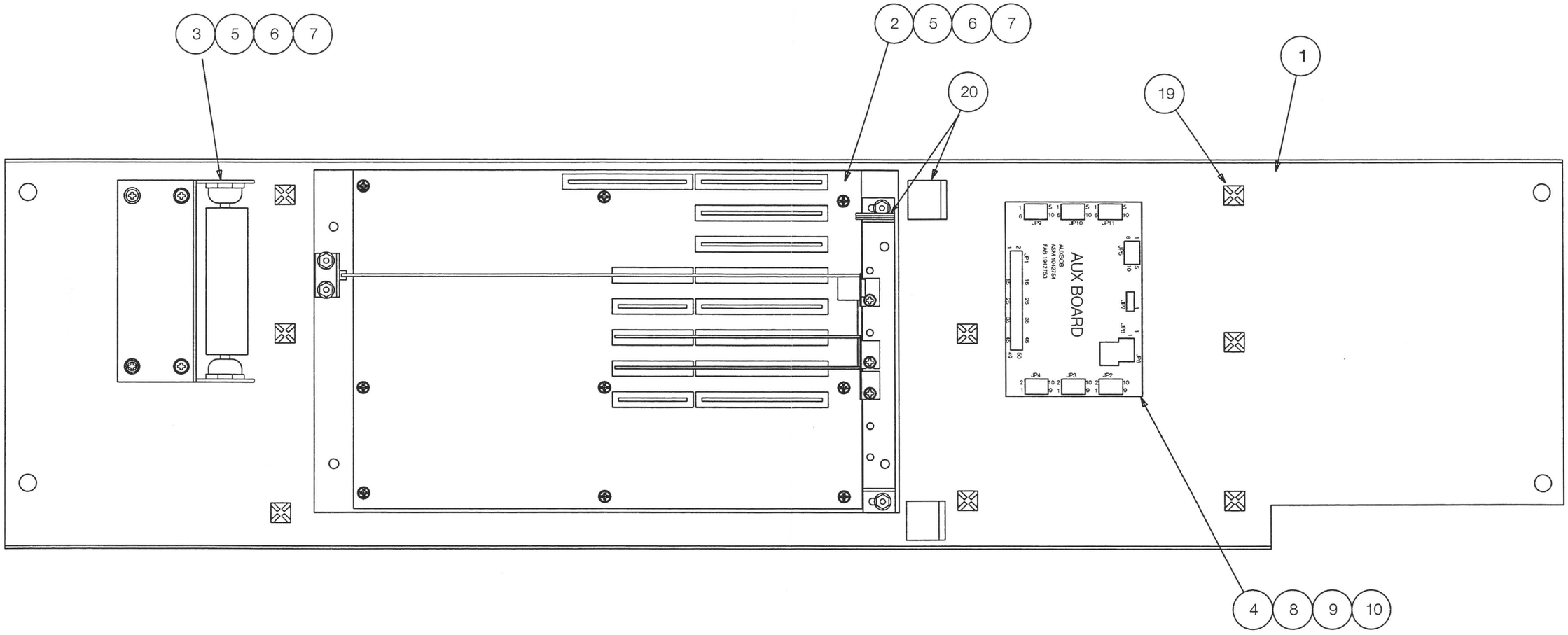
| Item | Code No. | Description |
|---|---|---|
| 1 | 3194-3147 | Weld Door |
| 2 | 3194-2542 | Filter Cover |
| 5 | 3154-1864 | Door Lock (2) |
| 6 | 3154-1074 | Cable Pad Tie (5) |
| 7 | 1101-0267 | Plate, WAN, SAF |
| 8 | 3194-3491 | Mounting Brkt. |
| 9 | 3154-2061 | Print Pocket |
| 10 | 3150-7661 | Gasket, 1/2W, Blk (15) |
| 11 | 3150-7914 | Clip, Ribbon Cable (3) |
| 12 | 3150-7946 | Door Fan. |
| 13 | 3150-8990 | Finger Guard |
| 15 | 3150-6557 | Washer, Flat, #6 (7) |
| 16 | 3150-6589 | Washer, #6 Spring (11) |
| 17 | 3194-3165 | Marker Voltage |
| 18 | 3192-8858 | Nameplate, Code |
| 19 | 1101-0323 | Plate, Elect. Rtg. (2) |
| 21 | 3150-5511 | B.H.C.S., #6-32 x 0.375 (4) |
| 22 | 3150-6579 | Washer, Lock, #6 (4) |
| 23 | 3150-6535 | Nut, Hex, #6-32 (5) |
| 24 | 3150-6642 | Screw, 80-82DEG (2) |
| 25 | 3154-2042 | Disk Drive, 3.5 in. |
| 26 | 3194-2240 | Guide, 525 Door (2) |
| 27 | 3150-2328 | Neoprene, Adhesive Back |
| 28 | 3150-6401 | P.H.M.S., #4-40x.375 (4) |
| 29 | 3150-6556 | Washer, #4 Fl. Pl. (4) |
| 30 | 3150-6588 | Washer, #4 Spring (4) |
| 31 | 3150-9085 | Screw, Thd. Form. (3) |
| 32 | 3154-2076 | Pad, 4 x 6 Felt |
| 33 | 3150-8044 | Screw, Thd. Form |
| 34 | 3194-2239 | Door, 5.25 Floppy |
| 35 | 3154-2070 | Handle, 3 in. Crm |
| 36 | 3154-2074 | Spring, Extension |
| 37 | 3150-6671 | Screw 80-82 deg. |

# 12. Parts Breakdown




**Door Assembly**
**Dwg. No. 3194-3186**




**Computer Panel Assembly**
**Dwg. No. 3194-3118 Rev. A**

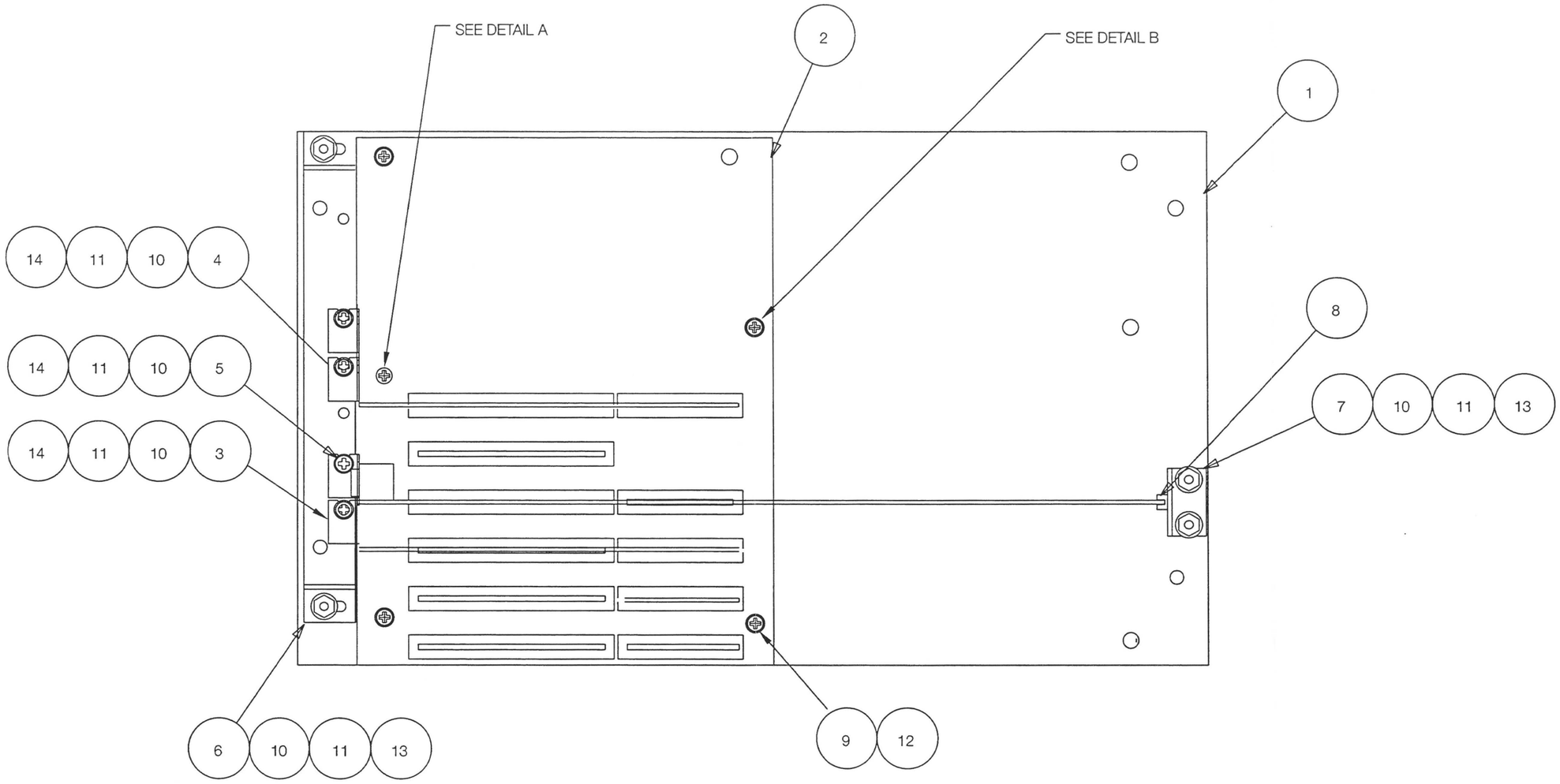
## COMPUTER PANEL ASSEMBLY — Dwg. No. 3194-3118

| Item | Code No. | Description |
|---|---|---|
| 1 | 3194-3093 | Detail Computer Panel |
| 2 | 3194-3156 | Logic Chassis |
| 3 | 3194-3449 | Assy. Hard Disk Drive |
| 4 | 3194-2754 | AUXBOB Assy |
| 5 | 3150-6441 | P.H.M.S., #10-32 x 0.500 (8) |
| 6 | 3150-6557 | Washer, Flat, #6 (8) |
| 7 | 3150-6591 | Washer, Spring (8) |
| 8 | 3150-6411 | P.H.M.S., #6-32 UNC-2A x 0.625 (4) |
| 9 | 3150-6579 | Washer, Lock, #6 (9) |
| 19 | 3154-1074 | Clamp, Cable (8) |
| 20 | 3150-7914 | Clip, Ribbon Cable (3) |

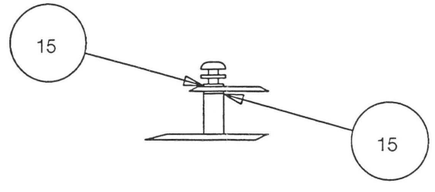
# 12. Parts Breakdown

## CARD CHASSIS — Dwg. No. 3194-3156

| Item | Code No. | Description |
|---|---|---|
| 1 | 3194-4049 | 486 Motherboard |
| 2 | 3154-2725 | Label |
| 3 | 3154-2574 | I/O Expansion Board |
| | 3154-3274 | Video Card |
| | 3194-4357 | BMDC3SC Final Assembly |
| 6 | 3194-2990 | Bracket, Card Lock |
| | 3194-2991 | PC Card Bracket |
| 8 | 3154-2541 | Guide Card |
| 9 | 3150-6410 | Scr, PHP, #6-32x1/2 (9) |
| 10 | 3150-6557 | Washer, Flat, #6, 5/16"OD (8) |
| 11 | 3150-6589 | Washer, Lock, Splt #6 (8) |
| 12 | 3150-6579 | Washer, Lock , It #6 (9) |
| 13 | 3150-6535 | Hex Nut (4) |
| 14 | 3150-6407 | Scr, PHMS (4) |
| 15 | 3154-2887 | Washer, Flat Fibre #6 (2) |
| 16 | 3154-2893 | Standoff, 6-32 x 9/16 lg. |

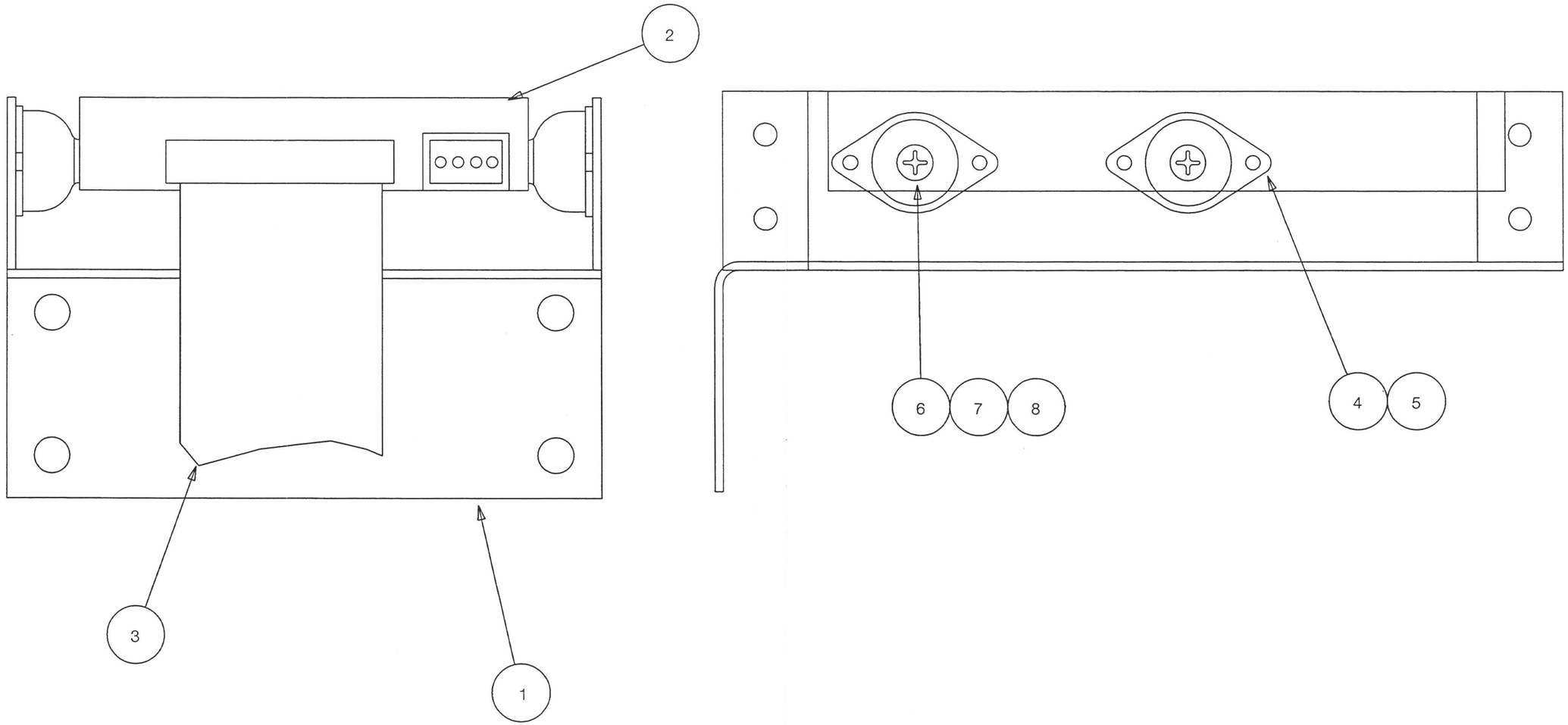


DETAIL A




DETAIL B

**Card Chassis**
**Dwg. No. 3194-3156 Rev. F**



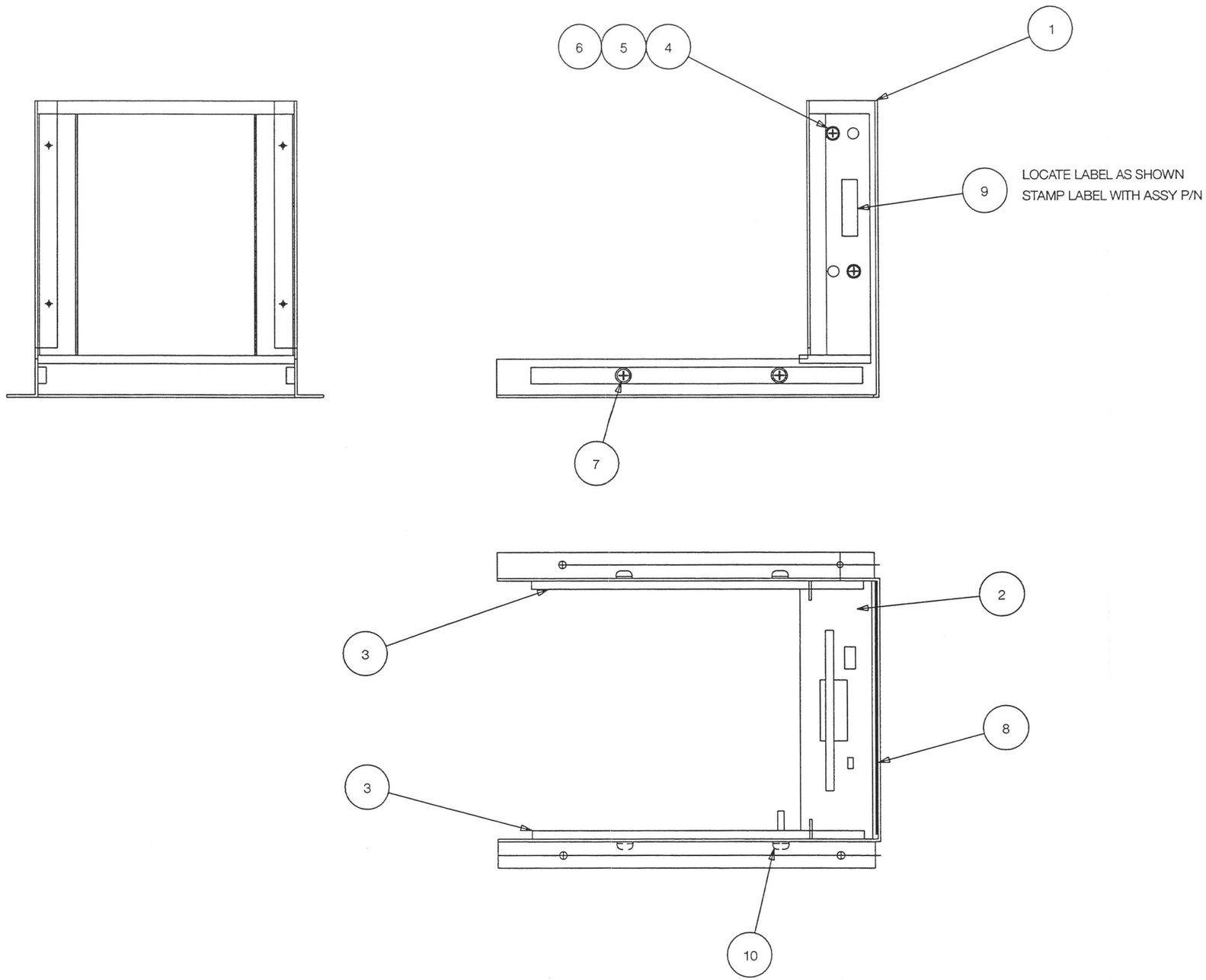

**Hard Drive Assembly**
**Dwg. No. 3194-3449**

## HARD DISK DRIVE ASSEMBLY — Dwg. No. 3194-3449

| Item | Code No. | Description |
|---|---|---|
| 1 | 3194-2312 | Hard Drive Mount |
| 2 | 3154-2177 | Hard Drive |
| 3 | 3154-2401 | Data Cable 40 pin |
| 4 | 3154-2156 | Isolators, Vibration (4) |
| 5 | 3150-0245 | Pop Rivet (8) |
| 6 | 3150-6409 | Scr, PHP, #6-32x3/8 (4) |
| 7 | 3150-6557 | Washer, Flat #6, 5/16" OD |
| 8 | 3150-6579 | Washer, Lock It, #6 (4) |

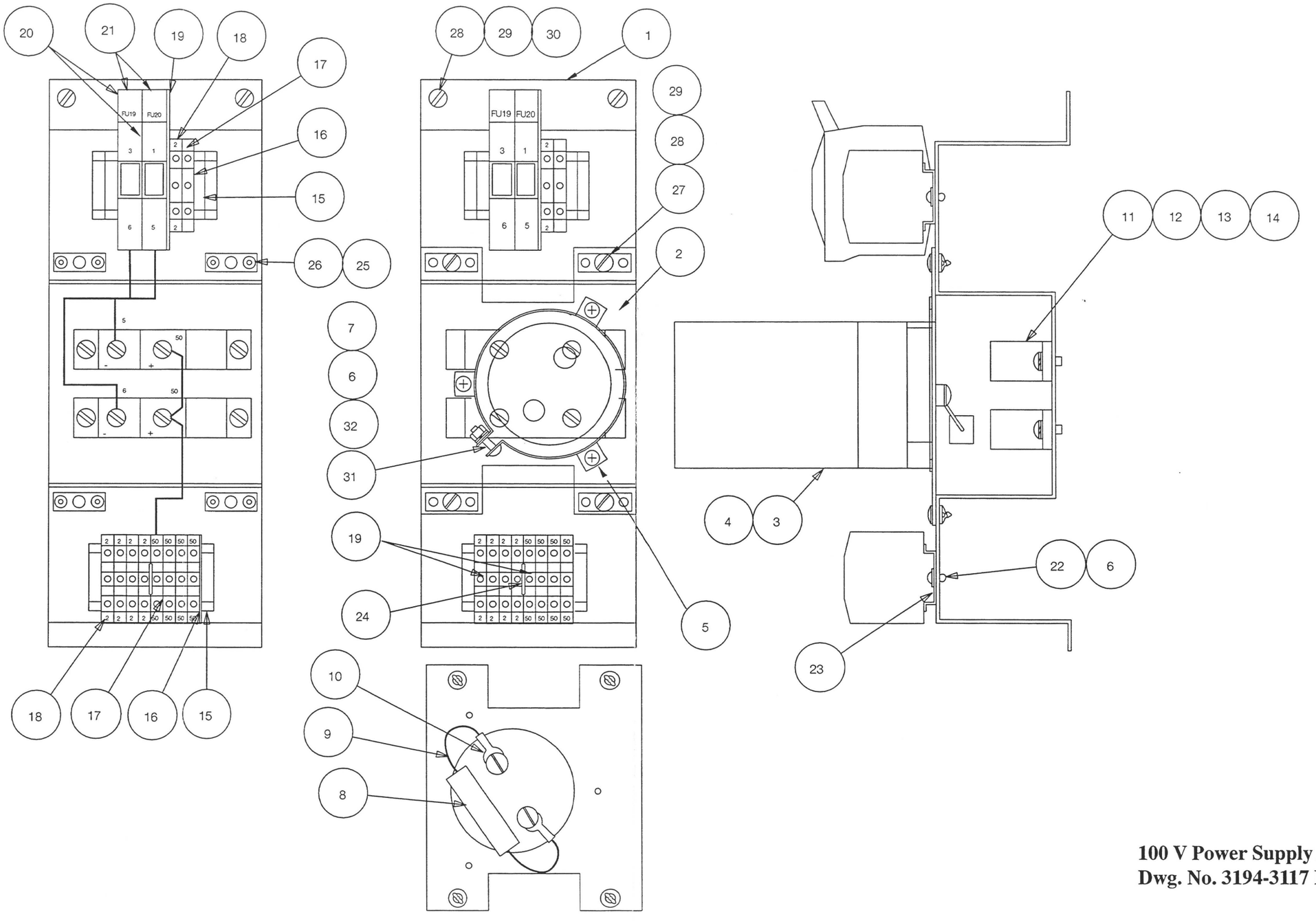
## FLOPPY DRIVE ASSEMBLY — Dwg. No. 3194-3530

| Item | Code No. | Description |
|---|---|---|
| 1 | 3194-3491 | Mounting Bracket Disk Drive |
| 2 | 3154-2042 | Disk Drive 3.5" |
| 3 | 3194-2240 | Door Guide (2) |
| 4 | 31506401 | Scr, PHP, #4-40 x 3/8 (4) |
| 5 | 31506556 | Washer, Flat #4 (4) |
| 6 | 31506588 | Washer, Lock Splt #4 (4) |
| 7 | 31509085 | Scr, TF HWHP, #6-32 x 3/8 (3) |
| 8 | 3150-2328 | Neoprene Adh. Back |
| 9 | 3154-2725 | Label |
| 10 | 3150-8044 | Scr, TF, HWHP, #6 - 32 x 3/4 |




**Floppy Drive Assembly**
**Dwg. No. 3194-3530 Rev. A**

# 12. Parts Breakdown




**100 V Power Supply Assy.**
**Dwg. No. 3194-3117 Rev. A**

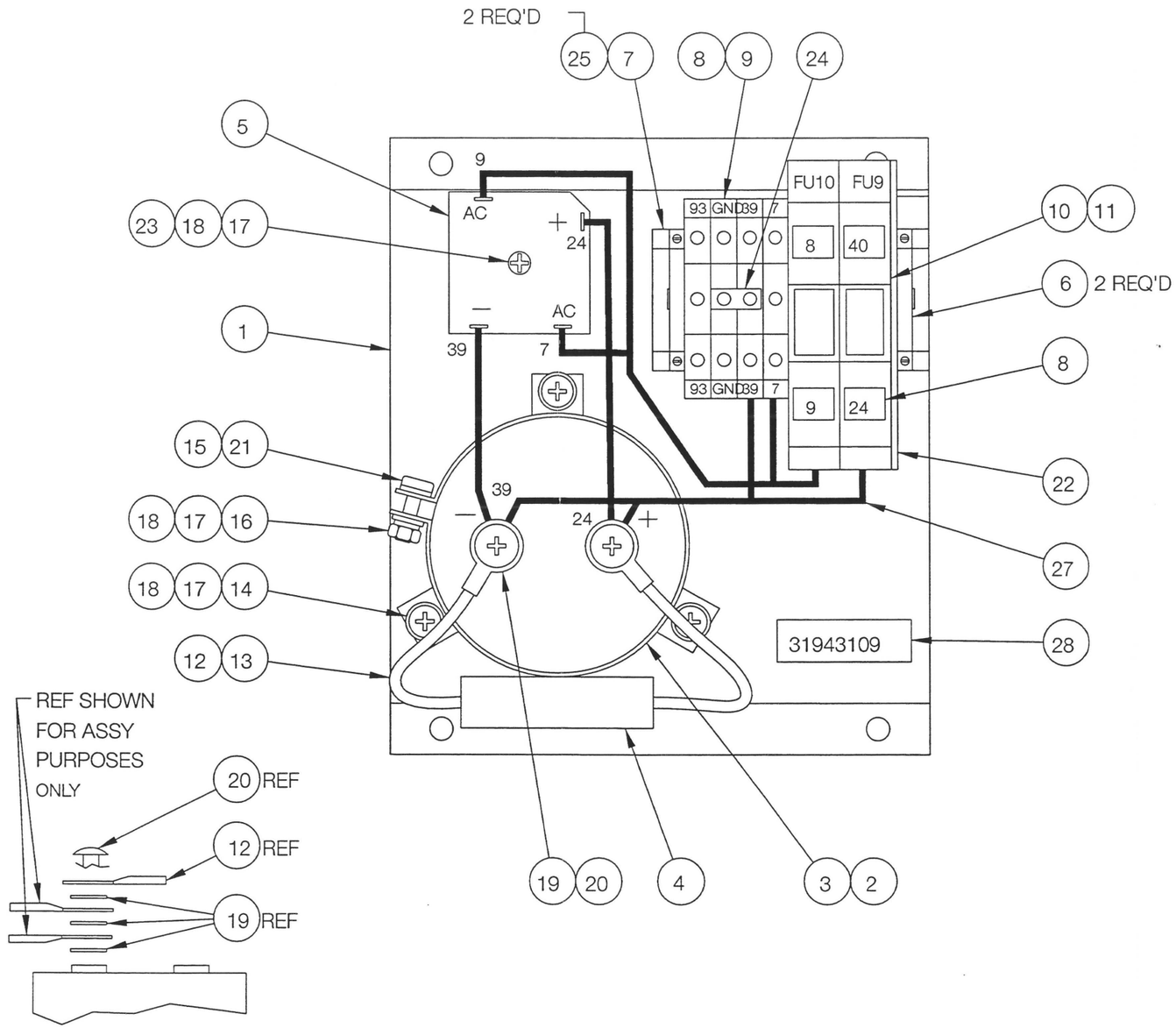
## 100V POWER SUPPLY ASSEMBLY — Dwg. No. 3194-3117

| Item | Code No. | Description |
|---|---|---|
| 1 | 3194-3094 | 100V Power Supply Chassis |
| 2 | 3194-3095 | Cover |
| 3 | 3154-2615 | Capacitor 15WVDC, 200VDC |
| 4 | 3150-6542 | Clamp, Capacitor |
| 5 | 3150-9085 | Screw, #6-32 x 0.500 (3) |
| 6 | 3150-6557 | Washer, Flat, #6 (5) |
| 7 | 3150-6589 | Washer, Spring Lock, #6 |
| 8 | 3150-4818 | Res, FXD, 3.5K Ohm |
| 10 | 3150-0531 | Term-Ring, 22/16, #10, Red (2) |
| 11 | 3154-1781 | Block, Assy, 800V (2) |
| 12 | 3150-6441 | P.H.M.S., #10-32 UNF-2A x 0.500 (4) |
| 13 | 3150-6559 | Washer, Plain, #10 (4) |
| 14 | 3150-6591 | Washer, Spring Lock, #10 (4) |
| 15 | 3154-1663 | End, Type E-NS3, Clamp (4) |
| 16 | 3150-8438 | T-B, End Plate (2) |
| 17 | 3150-8130 | T-B, Terminal (10) |
| 18 | 3150-8911 | Tag, Dekafix (20) |
| 19 | 3150-8862 | T-B, Jumper |
| 20 | 3150-9943 | Fuse Holder (2) |
| 21 | 3154-1648 | Fuse, Slo Blo (2) |
| 23 | 3194-2868 | MTG Track, DIN Rail 35 mm x 8 ft. (2) |
| 24 | 3150-8130 | T-B Terminal |
| 25 | 3150-4981 | Recep, Steel (4) |
| 26 | 3150-3675 | Pop Rivet, SP-34-BS (8) |
| 27 | 3150-3874 | Fastener, Stud, 1/4 Turn (4) |
| 28 | 3150-2884 | Retainer (6) |
| 29 | 3150-4984 | Washer, Nylon (6) |
| 30 | 3154-2531 | Stud, 1/4 Turn, #82 (2) |
| 31 | 3150-6412 | P.H.M.S., #6-32 UNC-2A x 0.750 |
| 32 | 3150-6535 | Nut, Hex, #6-32 UNC-2B |

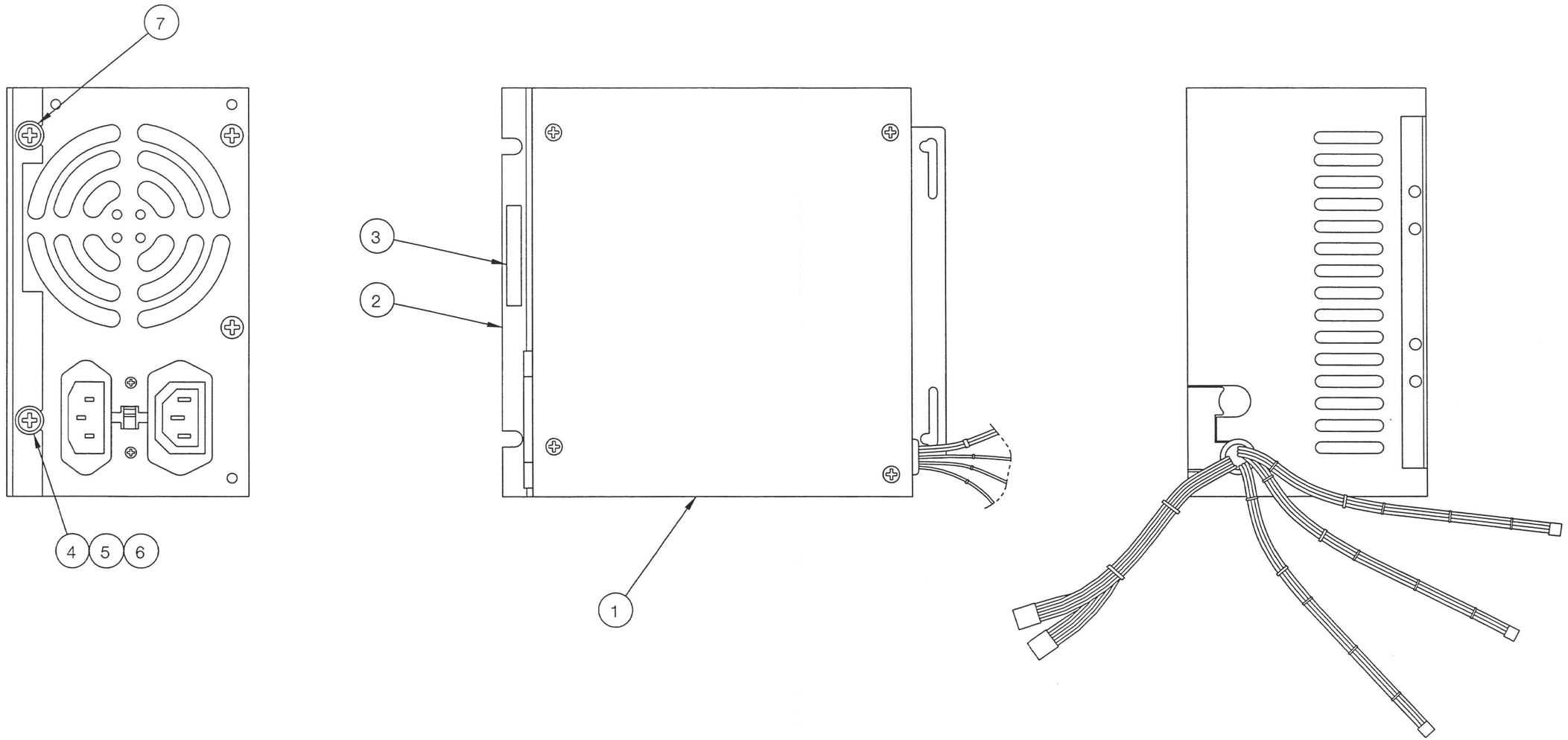
# 12. Parts Breakdown

## 24 VOLT POWER SUPPLY ASSEMBLY -- Dwg. No. 3194-3109

| Item | Code No | Description | Qty. |
|---|---|---|---|
| 1 | 31942789 | Base Plate, Power Supply | 1 |
| 2 | 31509003 | Cap | 1 |
| 3 | 31501075 | Clamp, Capacitor | 1 |
| 4 | 31504818 | Res, FXD, 1K Ohm | 1 |
| 5 | 31542530 | Bridge Rect | 1 |
| 6 | 31541663 | End Type Clamp | 2 |
| 7 | 31942868 | Mtg Track Din Rail | 1 |
| 9 | 31508130 | Term. Block | 4 |
| 10 | 31509942 | Fuseholder | 2 |
| 11 | 31508852 | Fuse, Type MDA | 2 |
| 12 | 31500531 | Term-Ring, PIDG, 22/16 #10 | 2 |
| 14 | 31506409 | Scr, PHP #6-32x3/8 | 3 |
| 15 | 31506574 | Washer, Lk Et #6 | 1 |
| 16 | 31506535 | Hex Nut #6-32 | 1 |
| 17 | 31506577 | Washer, Flat #6 5/16"OD | 5 |
| 19 | 31506581 | Washer, Lk It #10 | 6 |
| 20 | 31506440 | Scr, PHP #10-32x3/8 | 2 |
| 21 | 31506412 | Scr, PHP #6-32x3/4 | 1 |
| 22 | 31509944 | Fuseholder End Plt | 1 |
| 23 | 31506411 | Scr, PHP #6-32x5/8" lg | 1 |
| 24 | 31508133 | Terminal Block 2 Pole Jumper | 1 |
| 26 | 31506558 | Washer, Flat, Plain | 2 |
| 27 | 31943552 | Parts for Wiring 24V | 1 |
| 28 | 31542725 | Label | 1 |




**24 Volt Power Supply**
**Dwg. No. 3194-3109 Rev. D**




**Logic Power Supply**
**Dwg. 3194-2930 Rev. AB**

## LOGIC POWER SUPPLY — Dwg. No. 3194-2930

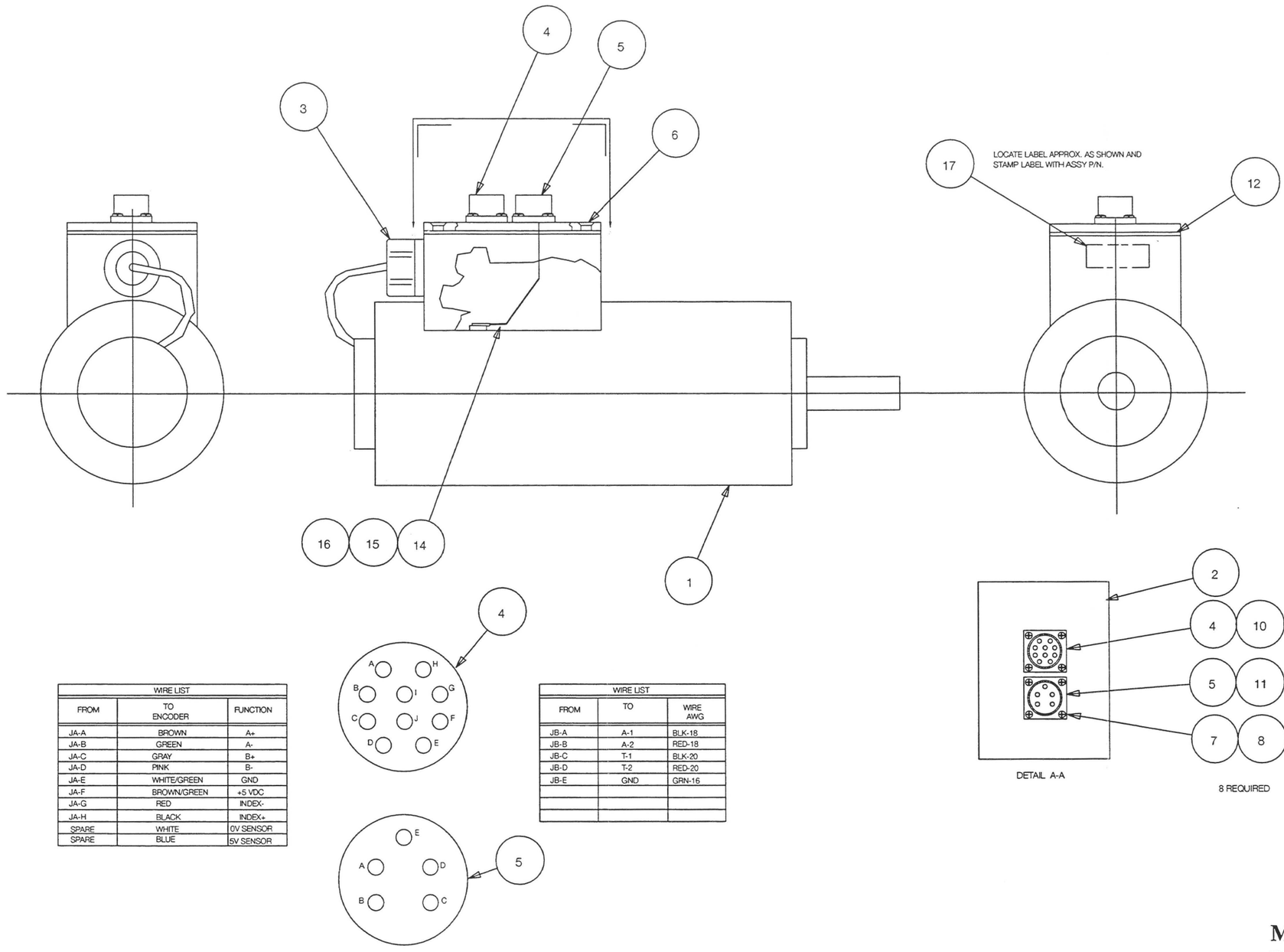
| Item | Code No. | Description | Qty. |
|---|---|---|---|
| 1 | 3194-3465 | Power Supply Assy. | 1 |
| 2 | 3194-2548 | Mounting Bracket, Power Supply | 1 |
| 3 | 3154-2725 | Label | |
| 6 | 3154-2250 | BHCS, M3 x .5 x 10 mm | 1 |
| 7 | 3150-6409 | Scr., PHP, #6-32 x 3/8 | 1 |
| 8 | 31506557 | Washer, Flat #6 5/16"OD | 2 |
| 9 | 3150-6589 | Washer, Lock Splt #6 | 2 |

# 12. Parts Breakdown

## MOTOR ASSEMBLY — Dwg. No. 3194-3651

| Item | Code No. | Description | Qty. |
|---|---|---|---|
| 1 | 31943650 | Installation Instructions | 1 |
| 2 | 31937757 | Motor Cable Cover Plate | 1 |
| 3 | 31504221 | Conn. Str. .500" | 1 |
| 4 | 31500331 | Conn. Rcpt. Box Mtg. | 1 |
| 5 | 31501245 | Conn. Rcpt. Box Mtg. | 1 |
| 6 | 31938894 | Screw, Flat Head Modified | 4 |
| 7 | 31506401 | Scr, PHP #4-40x3/8 | 8 |
| 8 | 31506556 | Washer, Flat #4 | 8 |
| 9 | 31506588 | Washer, Lk Splt #4 | 8 |
| 12 | 3193802 | Gasket, Top 1/16" Thk | 1 |
| 13 | 31505104 | Gasket, Plain | 2 |
| 14 | 31505179 | Wire Non-Flex. | 1 |
| 15 | 31500531 | Term-Ring PIDG 22/16 #10 | 1 |
| 16 | 31506580 | Washer, Lock Type A No. 8 | 1 |
| 17 | 31542725 | Label | 0 |
| 18 | 31500583 | Cable Tie 4" | 6 |

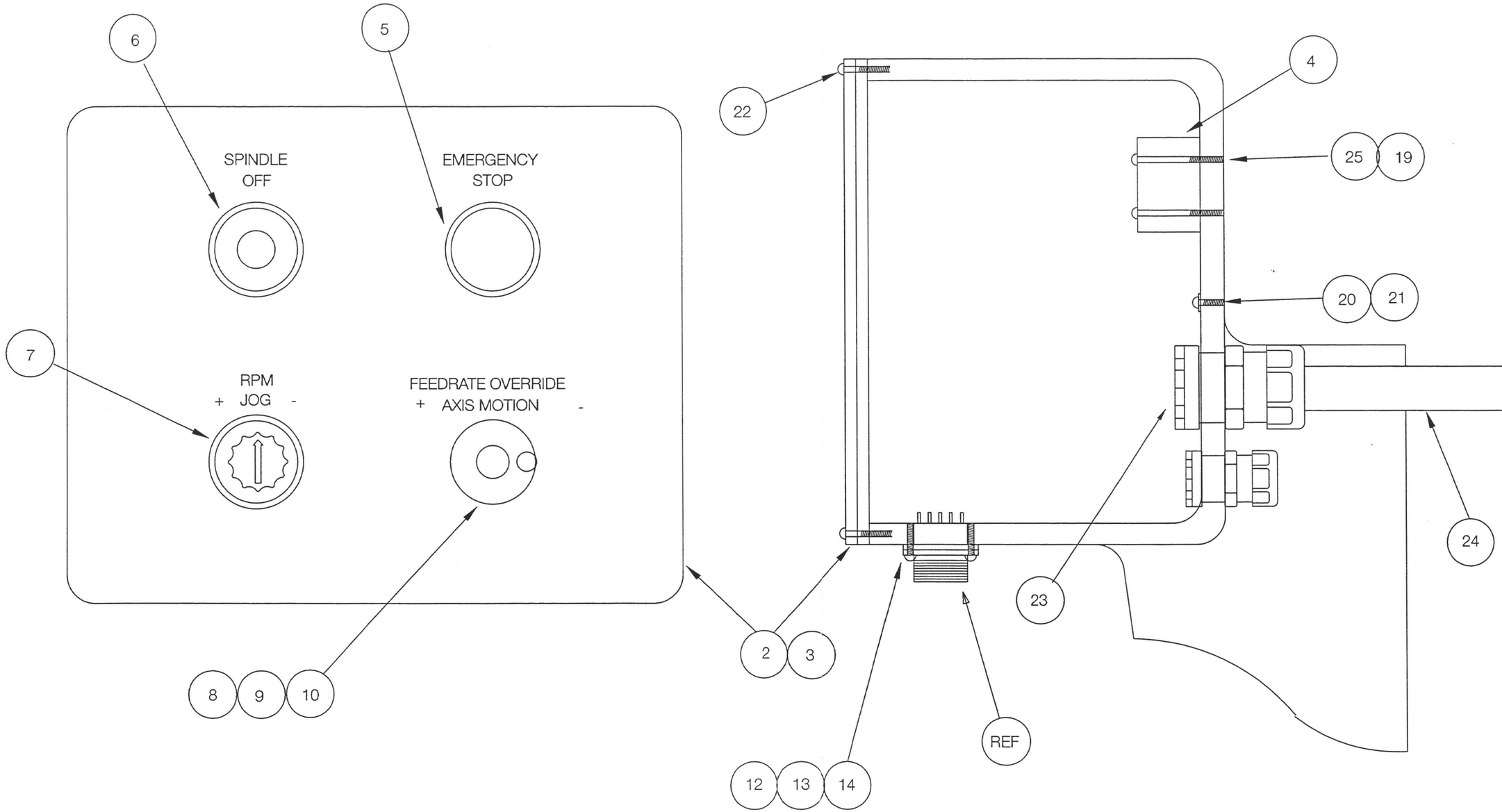
# 12. Parts Breakdown




| WIRE LIST | | |
|---|---|---|
| FROM | TO ENCODER | FUNCTION |
| JA-A | BROWN | A+ |
| JA-B | GREEN | A- |
| JA-C | GRAY | B+ |
| JA-D | PINK | B- |
| JA-E | WHITE/GREEN | GND |
| JA-F | BROWN/GREEN | +5 VDC |
| JA-G | RED | INDEX- |
| JA-H | BLACK | INDEX+ |
| SPARE | WHITE | 0V SENSOR |
| SPARE | BLUE | 5V SENSOR |

| WIRE LIST | | |
|---|---|---|
| FROM | TO | WIRE AWG |
| JB-A | A-1 | BLK-18 |
| JB-B | A-2 | RED-18 |
| JB-C | T-1 | BLK-20 |
| JB-D | T-2 | RED-20 |
| JB-E | GND | GRN-16 |
| | | |
| | | |
| | | |

**Motor Assembly**
**Dwg. No. 3194-3651**




**Operator Control Assembly**
**Dwg. No. 3194-3133 Rev. C**

## OPERATOR CONTROL ASSEMBLY — Dwg. No. 3194-3133

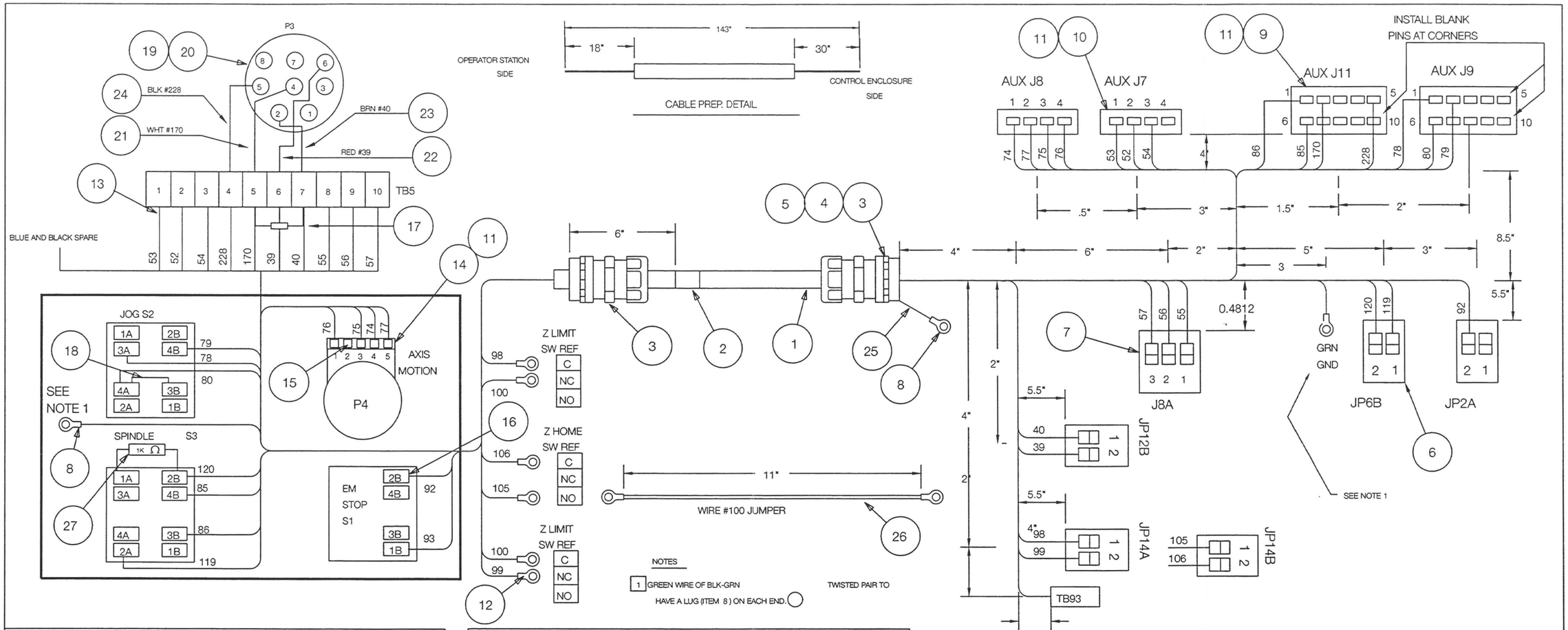
| Item | Code No. | Description | Qty. |
|---|---|---|---|
| 1 | 12742801 | Operator Control Box | 1 |
| 2 | 11742802 | Operator Box Cover | 1 |
| 3 | 11742803 | Cover Gasket | 1 |
| 4 | 31501839 | T-B Barrier | 1 |
| 5 | 31508790 | EStop Red Pushbutton | 1 |
| 6 | 31540630 | Pushbutton Switch, 24V | 1 |
| 7 | 31504479 | Switch Jog Spring | 1 |
| 8 | 31540275 | Knob, Crank Encoder | 1 |
| 9 | 31542567 | Encoder, Panel Mount | 1 |
| 10 | 31506576 | Lockwasher, External Tooth | 1 |
| 12 | 31501316 | Gasket | 1 |
| 13 | 31506168 | Conn. Sealing Cap | 1 |
| 14 | 31505528 | Scr. BHC #4-40x3/8 | 4 |
| 19 | 31506423 | Screw, Pan Hd 8-32x1/2" | 2 |
| 20 | 31506421 | Scr, Pan Hd, 8-32x3/8" | 1 |
| 21 | 31506575 | Washer, Lk Et #10 | 1 |
| 22 | 31505520 | Scr, BHC #8-32x3/8 | 4 |
| 23 | 11012309 | Bushing | 1 |
| 24 | 31943134 | Operator Control Cable | 1 |
| 25 | 31506580 | Washer, Lock Type A No. 8 | 2 |

# 12. Parts Breakdown

## OPERATOR CONTROL CABLE — Dwg. No. 3194-3134

| Item | Code No. | Description | Qty. |
|---|---|---|---|
| 1 | 31540768 | Grey Cable | 12 |
| 2 | 31540065 | Cable Marker Label | 1 |
| 3 | 31502311 | Conn. Str., .500" | 2 |
| 4 | 31504219 | Seal O Rin g, Cnd. Ftg. .500" | 1 |
| 5 | 31503425 | Locknut, Cnd. Ftg. .50" size | 1 |
| 6 | 31542490 | Terminal Block | 5 |
| 7 | 31541832 | Term Blk Plug | 1 |
| 8 | 31500531 | Term-Ring | 2 |
| 9 | 31506073 | Connector | 2 |
| 10 | 31540284 | Conn. El. Housing, Single #1 | 2 |
| 11 | 31505932 | Contact Receptacle | 23 |
| 12 | 31500529 | Term-Ring PIDG 22/16 #6 | 6 |
| 13 | 31500533 | Term-Spade Lug 22/16 awg | 16 |
| 14 | 31542570 | Housing, Single Row, 5 pos. | 1 |
| 15 | 31542571 | Key Plug amp #86286-1 | 1 |
| 16 | 31507678 | Quick Disconn Crimp Ins | 13 |
| 17 | 31500822 | Resistor 1/4W 5% 3.3K Ohm | 1 |
| 18 | 31505815 | Blue Wire 22 awg | .50 ft. |
| 19 | 31506165 | Recept. Sq. Flg. Rvs. Sex | 1 |
| 20 | 31508343 | Contact Socket 24-20 awg | 4 |
| 21 | 31505817 | Irradiated Insulated Wire | .50 ft. |
| 22 | 31505812 | Irradiated Insulated Wire | .50 ft. |
| 23 | 31505811 | Irradiated Insulated Wire | .50 ft. |
| 24 | 31505810 | Irradiated Insulated Wire | .50 ft. |
| 25 | 31505814 | Green Flex Wire, 22 awg | 1.50 ft. |
| 26 | 31542460 | Wire 18 awg, 300 v w/o Nylon | 1 ft. |
| 27 | 31500687 | Resistor, 1/2W, 5%, 100 Ohms | 1 |

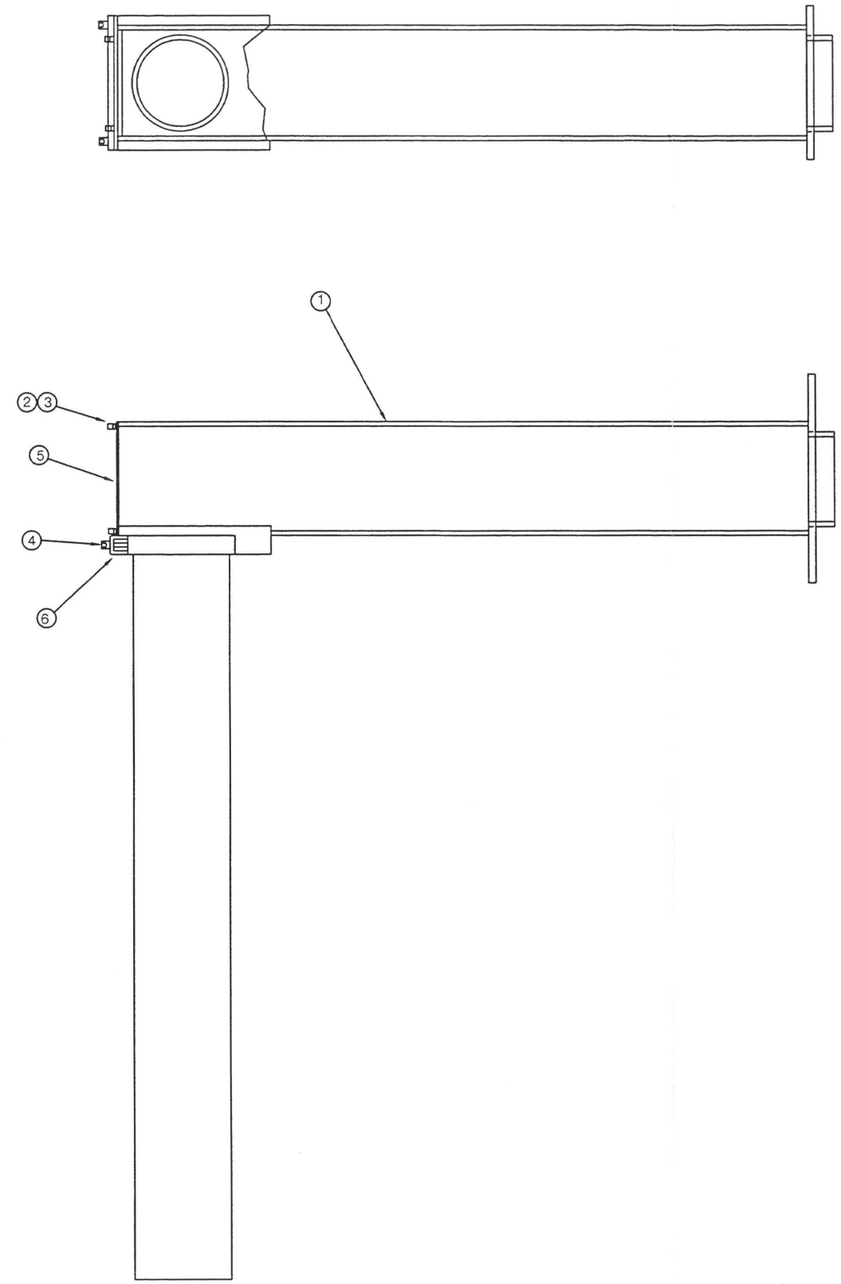
# 12. Parts Breakdown

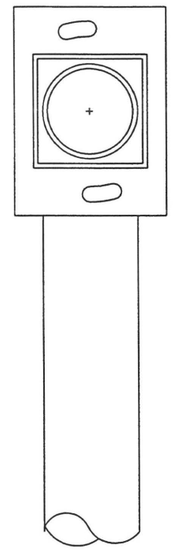



| WIRE TABLE | | | |
|---|---|---|---|
| WIRE NO. | COLOR | FROM | TO |
| 105 | RED | AUF- J14B-1 | Z LIMIT- NO |
| 106 | GRN | AUF- J24B-2 | Z LIMIT- C |
| 99 | BLK | AUF- J14A-2 | Z LIMIT- NC |
| 98 | ORG | AUF- J14A-1 | Z LIMIT- C |
| 56 | GRN | AUF- J8A-2 | TB5- 56 |
| 55 | BLU | AUF- J8A-1 | TB5- 55 |
| 57 | RED | AUF- J8A-3 | TB5- 57 |
| 53 | BLK | AUF-J7-1 | TB5-53 |
| 120 | GRN | AUF- J6B-2 | S3-2B |
| 119 | WHT | AUF- J6B-1 | S3-2A |
| 92 | WHT | AUF- J2A-2 | S1-2B |
| 93 | BLK | PS- TB-93 | S1-1B |
| 85 | RED | AUX- J11- 6 | S3-4B |
| 86 | BLU | AUX- J11- 1 | S3-3B |
| 40 | ORG | AUX- JP12- 1B | TB5-40 |
| 39 | RED | AUX- JP12- 2B | TB5-39 |

| WIRE TABLE | | | |
|---|---|---|---|
| WIRE NO. | COLOR | FROM | TO |
| 170 | YEL | AUX- J11- 2 | TB5-170 |
| 228 | BLK | AUX-J11-5 | TB5-228 |
| 79 | RED | AUX- J9- 2 | S2-4B |
| 78 | YEL | AUX- J9- 1 | S2-3A |
| 80 | BLK | AUX- J9- 6 | S2-4A |
| GND | GRN | CHASSIS GND | CHASSIS GND |
| 54 | BRN | AUX- J7- 3 | TB5-54 |
| 52 | BLK | AUX- J7- 2 | TB5-52 |
| SPARE | BLU | SPARE | SPARE |
| SPARE | BLK | SPARE | SPARE |
| 76 | RED | AUX- J8- 4 | P4- 1 |
| 74 | BRN | AUX- J8- 1 | P4- 4 |
| 77 | RED | AUX- J8- 2 | P4- 5 |
| 75 | WHT | AUX- J8- 3 | P4- 3 |

**Operator Station Cable**
**Dwg. No. 3194-3134**



**Horizontal Arm Assembly**
**Dwg. No. 3194-1269**

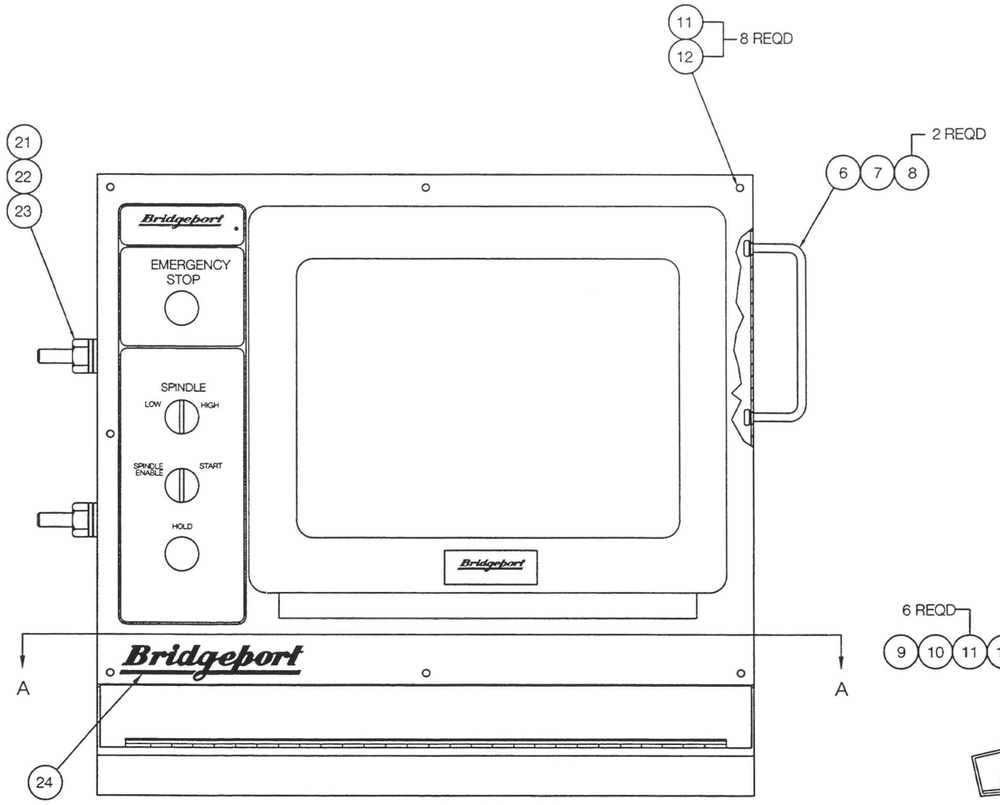
## HORIZONTAL ARM ASSEMBLY — Dwg. No. 3194-1269

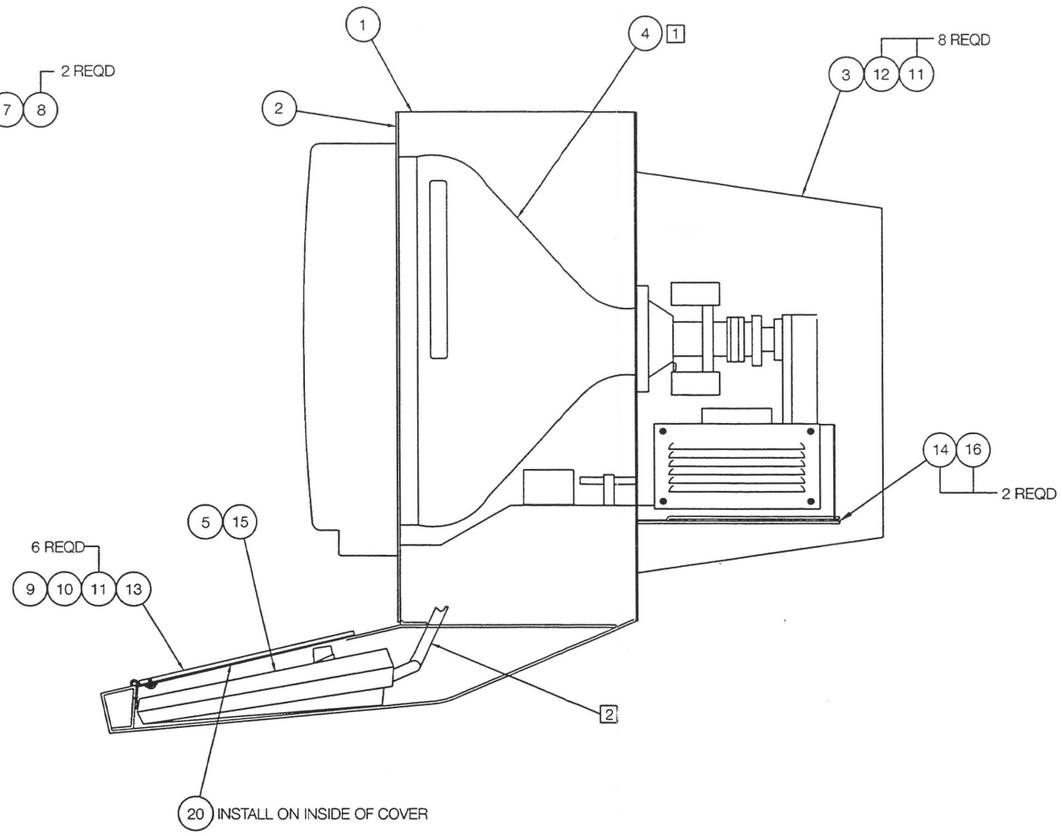
| Item | Code No. | Description | Qty. |
|---|---|---|---|
| 1 | 3194-1199 | Arm Weldment | 1 |
| 2 | 3150-5511 | Scr. BHC, #6-32x3/8 | 4 |
| 3 | 3150-6579 | Washer, Lock #6 | 4 |
| | 3150-6616 | Washer, Flat #6 | 4 |
| 4 | 1101-1034 | SHCS, .250-20 x .875" lg. | 2 |
| 5 | 3194-2413 | Cover | 1 |
| 6 | 3194-2365 | Arm Locking Bracket | 1 |
| 7 | 3150-2413 | Weather Strip Gasket | 1 |

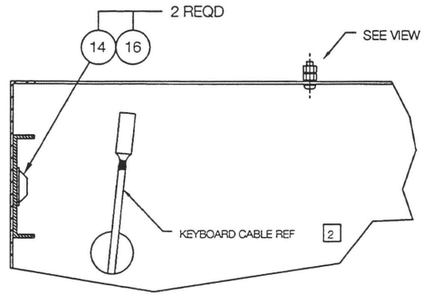
## CRT HOUSING ASSEMBLY — Dwg. No. 1259-7700

| Item | Code No. | Description | Qty. |
|---|---|---|---|
| 1 | 1159-7507 | CRT Weldment | 1 |
| 2 | 1259-7710 | Front Panel Assembly | 1 |
| 3 | 3194-3485 | Back Cover Assembly | 1 |
| 4 | 3150-0583 | Cable Tie, 4" | 6 |
| 5 | 3154-2966 | Keyboard | 1 |
| 6 | 3150-7420 | Handle | 1 |
| 7 | 3150-6433 | Screw Fastener #10-24 x 1/2 lg | 2 |
| 8 | 3150-6575 | Lock Washer, ET, #10 | 4 |
| 9 | 3150-5527 | Scr., BHC #4-40 x 1/4 lg | 6 |
| 10 | 3150-6588 | Lock Washer, #4 | 6 |
| 11 | 3150-7207 | Washer, Flat #4 | 22 |
| 12 | 3154-2250 | BHCS, M3 x .5 x 10 mm lg | 16 |
| 13 | 3194-3333 | Keyboard Cover | 1 |
| 14 | 3154-1074 | Cable Tie Pad | 4 |
| 15 | 3154-2963 | Keyboard Cover | 1 |
| 16 | 3150-0585 | Cable Tie 8" | 4 |
| 17 | 3150-6547 | Plain Hex Nut | 2 |
| 18 | 3150-8045 | Screw, TF, 10-32x 1/2 | 1 |
| 19 | 3150-6581 | Lock Washer #10 | 1 |
| 20 | 1101-0648 | Decal, DX-32 | 1 |
| 21 | 2171-2155 | Nut, M10 Hex | 2 |
| 22 | 2171-2084 | Washer, 10 mm Spring | 2 |
| 23 | 2171-2105 | Washer, Flat M10 | 2 |
| 24 | 6160-9047 | Bridgeport Decal | 1 |

# 12. Parts Breakdown

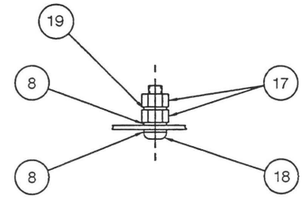



SECTION A-A

SCALE: NONE




VIEW B

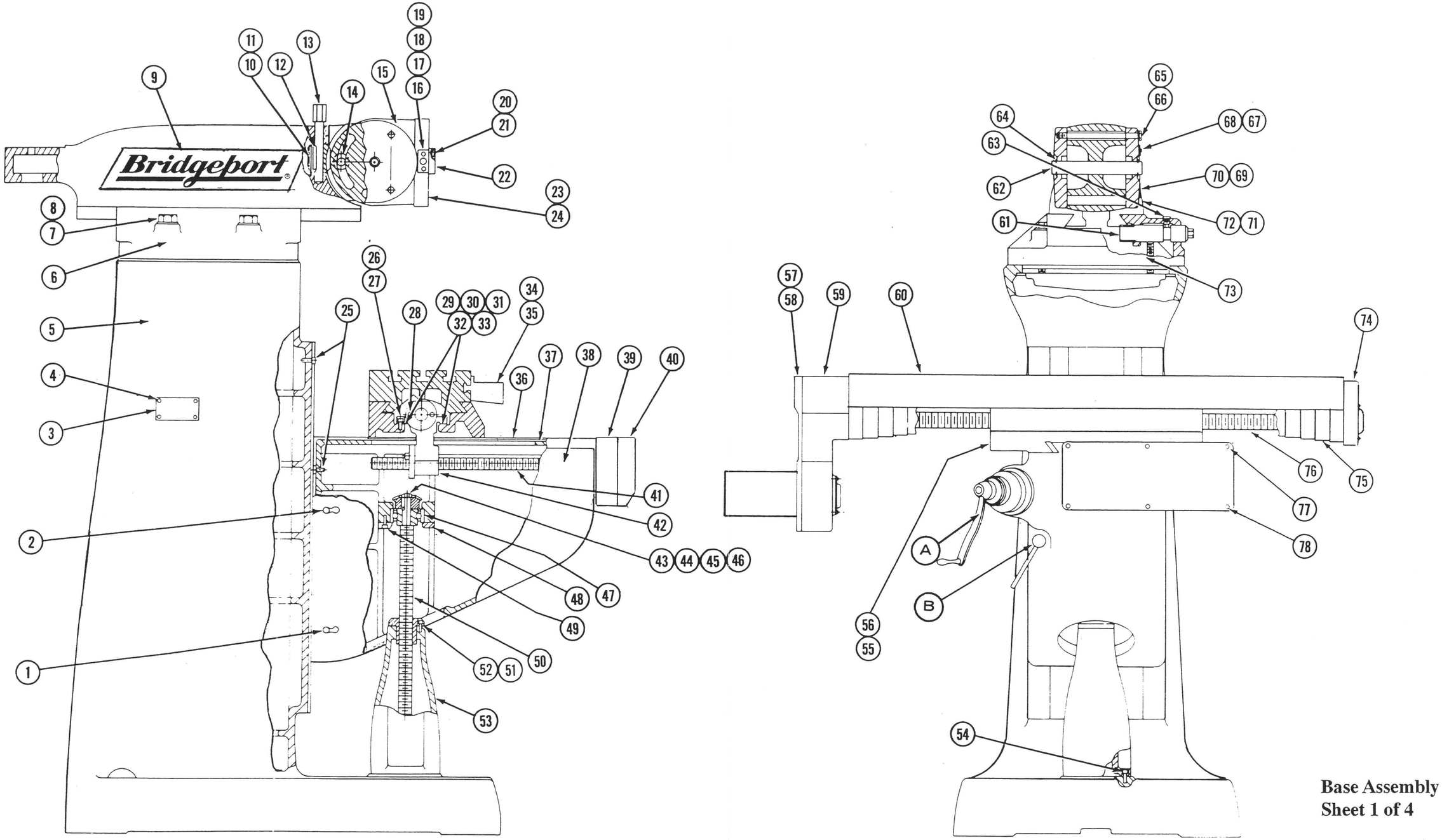
SCALE: NONE

2 ROUTE KEYBOARD CABLE THRU KEYBOARD TRAY AND UP THRU ACCESS HOLE IN BACK OF ITEM 1 AS SHOWN.

1 DRESS POWER AND SIGNAL CORD FROM BACK OF MONITOR ALONG BACK AND LEFT SIDE OF ITEM 1. SECURE WITH (6) ITEM 4 CABLE TIES.

NOTES:

**CRT Housing Assembly**
**Dwg. No. 597700 AA**




**Base Assembly - Sheet 1 of 4**

# 12. Parts Breakdown

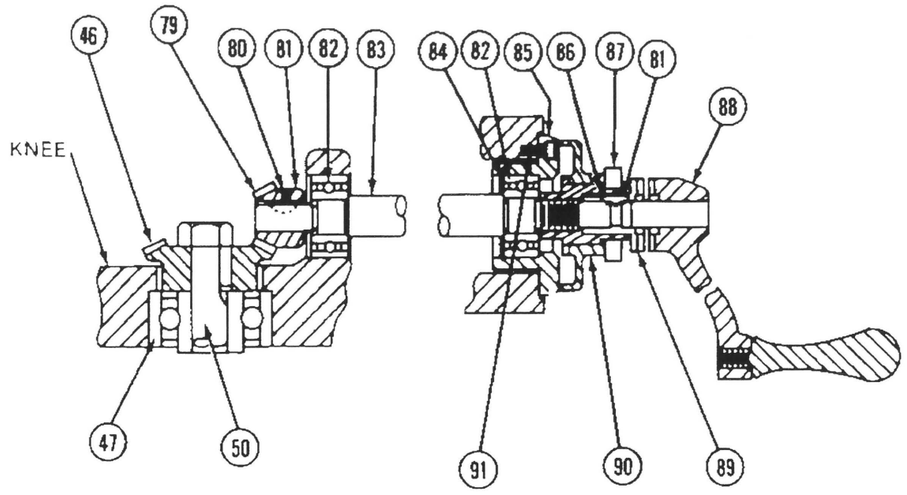
## BASE ASSEMBLY

| Item | Code No. | Description |
|---|---|---|
| 1 | 1-206-0425 | Lower Knee Lock Assembly |
| | 1-106-2179 | Handle, H-3305 |
| | 1-206-0119 | Table Lock Bolt |
| | 1-206-0423 | Lower Knee Plug |
| 2 | 1-206-9424 | Upper Knee Lock Assembly |
| | 1-106-2179 | Handle, H-3305 |
| | 1-206-0119 | Table Lock Bolt |
| | 1-206-0422 | Upper Knee Plug |
| 3 | 1-106-2834 | Nameplate |
| 4 | 1-101-1555 | Drive Screw |
| 5 | 1-274-9166 | Series I Column |
| 6 | 1-206-0208 | Turret |
| 7 | 1-106-1178 | H.H.C.S., 0.500-13 x 6.062 |
| 8 | 1-120-0109 | Washer |
| 9 | 1-206-0128 | Ram |
| 10 | 1-106-2206 | Adjustment Worm |
| 11 | 1-101-1216 | S.S.S., 10-32 x 0.187 |
| 12 | 1-206-0138 | Square Key, 0.188 x 1.938 |
| 13 | 1-206-0130 | Vertical Worm Shaft |
| 14 | 1-206-0328 | Clamping Bushing |
| 15 | 1-206-9013 | Ram Adapter |
| 16 | 1-101-1017 | S.H.C.S., 10-32 x 0.500 |
| 17 | 1-115-2094 | Spring Plunger |
| 18 | 1-206-9999 | Head Rotation Stop Pin |
| 19 | 1-265-0180 | Head Rotation Bracket |
| 20 | 1-101-1035 | S.H.C.S., 0.250-20 x 1.00 |
| 21 | 1-101-0590 | Roll Pin, 0.312 x 1.500 |
| 22 | 1-219-0178 | Head Tilting Gear |
| 23 | 1-106-0603 | Ram Adapter Scale |
| 24 | 1-198-0426 | Drive Screw #4 x 0.3 |
| 25 | 1-177-0252 | Stop Screw |
| 26 | 1-101-1074 | S.H.C.S., 0.375-16 x 1.000 |
| 27 | 1-101-0543 | Roll Pin, 0.187 x 1.000 |
| 28 | 1-101-1075 | S.H.C.S., 0.375-16 x 1.250 |
| 29 | 1-174-9049 | Shim, 0.0005 |
| 30 | 1-174-9050 | Shim, 0.001 |
| 31 | 1-174-9051 | Shim, 0.002 |
| 32 | 1-174-9052 | Shim, 0.003 |
| 33 | 1-174-9053 | Shim, 0.004 |
| 34 | 3-193-9514 | X-Axis Cover |
| 35 | 1-166-5494 | B.H.C.S., 10-32 x 0.250 |
| 36 | 1-106-0152 | Chip Guard |
| 37 | 1-106-0153 | Chip Guard |
| 38 | 1-274-9037 | Knee with Chrome |
| 39 | 1-274-9001 | Y-Axis Bracket |
| 40 | 1-274-9002 | Y-Axis Bracket Cover |
| 41 | 1-174-9020 | Y-Axis Ballscrew (0.200 in. Lead) |
| 42 | 1-274-9023 | Ballscrew Bracket |
| 43 | 1-101-1755 | Hex Jam Nut, 5-20 |
| 44 | 1-206-0072 | Knee Elevating Washer |
| 45 | 1-206-0071 | Key Square, 0.1875 |
| 46 | 1-106-2204 | Bevel Gear |
| 47 | 1-106-0205 | Bearing |
| 48 | 1-206-0070 | Bearing Retainer |
| 49 | 1-101-1031 | S.H.C.S., 0.250-20 x 0.625 |
| 50 | 1-206-0069 | Z-Axis Leadscrew |
| 51 | 1-206-0051 | Z-Axis Screw Nut |
| 52 | 1-101-1195 | B.H.C.S., 0.250-20 x 1.000 |
| 53 | 1-206-0207 | Pedestal |
| 54 | 1-101-1074 | S.H.C.S., 0.375-16 x 1.000 |
| 55 | 1-274-1380 | Saddle with Chrome |
| 56 | 1-206-0489 | Saddle Lubricating Kit (Sect. 6.1) |
| | 1-141-3235 | Drive Bushing (6) |
| | 1-141-3230 | Bracket |
| | 1-141-3236 | Tubing Clip (2) |
| | 1-141-0052 | 10-Way Junction Assembly |
| | 1-141-0063 | Junction |
| | 1-141-3219 | Compression Nut (8) |
| | 1-141-3221 | Compression Sleeve |
| | 1-141-3225 | Nylon Tubing, 0.156 OD (9 ft.) |
| | 1-141-3211 | Metering Unit (5) |
| | 1-141-3210 | Meter Unit (3) |
| | 1-141-3226 | Closure Plug |
| | 1-141-3220 | Compression Bushing |
| | 1-141-3224 | Brass Tubing, 0.156 OD (0.417 ft.) |
| | 1-141-3293 | Compression Sleeve |
| 57 | 1-274-9004 | X-Axis Bracket Cover |
| 58 | 1-101-1031 | S.H.C.S., 0.250-20 x 0.625 |
| 59 | 1-274-9003 | X-Axis Bracket |
| 60 | 1-206-0346 | 42 in. Table |
| 61 | 1-206-0255 | Ram Pinion |
| 62 | 1-206-1028 | Adapter Pivot Pin |
| 63 | 1-206-0140 | Ram Pinion Screw |
| 64 | 1-106-0892 | Retaining Ring (2) |
| 65 | 1-120-0109 | Washer |
| 66 | 1-106-1180 | H.H.C.S., 0.500-13 x 7.25 |
| 67 | 1-101-1552 | Drive Screw |
| 68 | 1-119-2856 | Ram Adapter Warning Plate |
| 69 | 1-101-1555 | Drive Screw |
| 70 | 1-106-2826 | Angle Plate |
| 71 | 1-106-0602 | Ram Scale |
| 72 | 1-198-0426 | Drive Screw 3 4x.3 |
| 73 | 1-206-0144 | Turret Miller Spider |
| 74 | 1-274-9015 | Table End Bracket |
| 75 | 1-174-9030 | Cover |
| 76 | 1-174-9019 | X-Axis Ballscrew (0.200 in. Lead) |
| 77 | 1-101-1041 | S.H.C.S., 0.250-20 x 1.625 |
| 78 | 1-101-1034 | S.H.C.S., 0.250-20 x 0.875 |
| 79 | 1-106-2205 | Pinion Gear |
| 80 | 1-101-1220 | S.S.S., 0.250-20 x 0.250 |

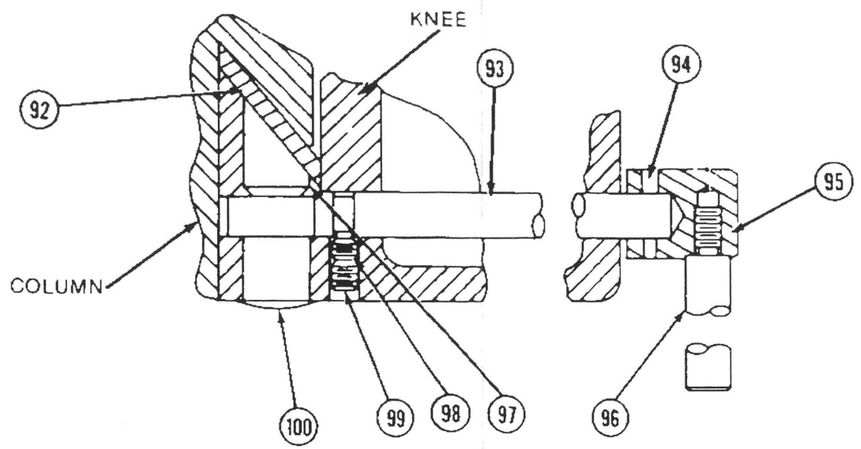
# 12. Parts Breakdown

## BASE ASSEMBLY

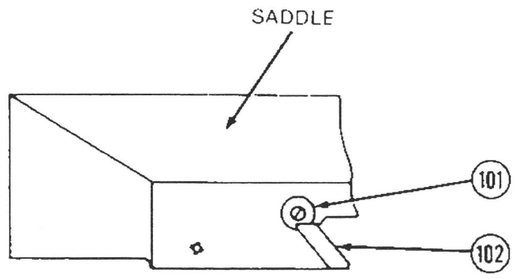
| Item | Code No. | Description |
|---|---|---|
| 81 | 1-101-3078 | #7 Woodruff Key |
| 82 | 1-106-0204 | Bearing (2) |
| 83 | 1-206-0147 | Gear Shaft |
| 84 | 1-165-0895 | Retaining Ring |
| 85 | 1-206-0210 | Bearing Retainer |
| 86 | 1-206-0077 | Dial Holder |
| 87 | 1-206-0078 | Knurled Dial Locknut |
| 88 | 1-206-1249 | Knee Crank Assembly |
| 89 | 1-206-0079 | Clutch Sleeve |
| 90 | 1-206-0076 | Z-Axis Inch Dial |
| 91 | 1-101-1030 | S.H.C.S., 0.250-20 x 0.500 |
| 92 | 1-206-0146 | Knee to Column Gib |
| 93 | 1-206-0148 | Knee Locking Camshaft |
| 94 | 1-101-0409 | Taper Pin #1 x 1.000 |
| 95 | 1-206-0091 | Cam Shaft Hub |
| 96 | 1-206-0092 | Knee Locking Handle |
| 97 | 1-206-0089 | Knee Lock Plunger |
| 98 | 1-101-1375 | S.S.S., 0.312-18 x 0.312 |
| 99 | 1-101-1270 | S.S.S., Knurled 0.312-18 x 0.312 |
| 100 | 1-101-0786 | Knee Gib Lock Pin Plug |
| 101 | 1-106-0088 | Gib Adjustment Screw |
| 102 | 1-206-0124 | Saddle to Knee Gib |
| 103 | 1-106-2405 | Felt Wiper (2) |
| 104 | 1-101-1031 | S.H.C.S., 0.250-20 x 0.625 |
| 105 | 1-106-0093 | Left Side Wiper Holder |
| 106 | 1-106-0094 | Right Side Wiper Holder |
| 107 | 1-206-0141 | Untapped Ram Clamp |
| 108 | 1-206-0137 | Ram Clamp Bar |
| 109 | 1-101-0770 | Rivet Pin |
| 110 | 1-206-0136 | Tapped Ram Clamp |
| 111 | 1-115-2802 | Positioning Plate |
| 112 | 1-101-1555 | Drive Screw |
| 113 | 1-106-0112 | Ram Lock Stud (2) |
| 114 | 1-278-0466 | Adjustable Motor Assembly |
| | 1-101-1207 | S.S.S., 8-32 x 0.250 |
| | 1-178-0468 | Timing Pulley, 12T |
| | 1-178-0511 | S.S.S., 0.250-28 x 0.37 |
| | 1-278-0467 | Timing Collar |
| | 1-278-0469 | Timing Bushing |
| 115 | 1-274-9041 | Motor Mounting Adapter (2) |
| 116 | 1-101-0173 | F.H.C.S., 0.312-24 x 0.562 Set |
| 117 | 1-142-1984 | Washer, 0.343 (8) |
| 118 | 1-101-1050 | S.H.C.S., 0.312-18 x 0.500 (8) |
| 119 | 1-119-1965 | External Lock Washer, 0.312 Set |
| 120 | 1-165-2116 | Timing Special Belt |
| 121 | 1-177-0151 | Flat Washer, 1.125 x 531 x 0.187 |
| 122 | 1-101-0301 | Locknut (2) |
| 123 | 1-174-9044 | Taper Lock Bushing (2) |
| 124 | 1-174-9043 | Timing Pulley (24T) (2) |
| 125 | 1-206-0075 | Bearing Retainer Ring (2) |
| 126 | 1-101-1076 | S.H.C.S., 0.375-16 x 1.500 |
| 127 | 1-106-0203 | Bearing (2) |
| 128 | 1-274-9027 | X-Axis Bearing Spacer |
| 129 | 1-278-0491 | Motor Pulley Access Cover (2) |
| 130 | 1-166-5162 | B.H.C.S., 10-32 x 0.375 |
| 131 | 1-166-5280 | #222 Loctite |
| 132 | 1-101-1130 | F.H.C.S., 10-32 x 0.500 |
| 133 | 1-274-9024 | X-Axis Bearing Plate |
| 134 | 1-274-9028 | Y-Axis Bearing Spacer |
| 135 | 1-165-2113 | Timing Belt |
| 136 | 1-206-0482 | Table/Saddle Gib Chrome |
| 137 | 1-101-1250 | S.S.S., 0.500-13 x 0.375 |
| 138 | 1-274-9139 | Splash Cover |
| 139 | 1-101-1001 | S.H.C.S., 6-32 x 0.250 |
| 140 | 1-274-9149 | X-Axis Trip Dog Bracket |
| 141 | 1-171-1085 | S.H.C.S., 0.375-16 x 3.250 |
| 142 | 1-215-0321 | Tee Nut Stop Dog (2) |
| 143 | 3-193-9257 | X-Axis Cable Assembly |
| 144 | 1-101-1191 | B.H.C.S., 10-32 x 0.625 |
| 145 | 1-101-1072 | S.H.C.S., 0.375-16 x 0.875 |
| 146 | 1-274-9006 | X-Axis Mounting Block |
| 147 | 1-101-1082 | S.H.C.S., 0.375-16 x 2.750 |
| 148 | 1-274-9018 | X-Axis Trip Dog Bracket |
| 149 | 1-206-0123 | Knee Wiper Plate (2) |
| 150 | 1-106-2406 | Felt Wiper (4) |
| 151 | 1-101-1580 | O.H.M.S., 10-32 x 0.500 |
| 152 | 1-211-0069 | Knee Access Cover |
| 153 | 1-198-0449 | B.H.C.S., 0.250-20 x 0.375 |
| 154 | 1-274-9145 | Y-Axis CAM |
| 155 | 1-101-1033 | S.H.C.S., 0.250-20 x 0.75 |
| 156 | 3-193-9258 | Y-Axis Cable Assembly |
| 157 | 1-101-1010 | S.H.C.S. 10-24 x 0.50 |
| 158 | 1-274-0049 | Y-Axis CAM (Home Position) |
| 159 | 1-274-0048 | Y-Axis CAM (Forward Position) |
| 160 | 1-101-1010 | S.H.C.S. 10-24 x 0.50 |
| 161 | 1-117-1900 | Washer, #10 Flat (2) |
| 162 | 1-274-9146 | Bracket, Trip Dog |
| 163 | 1-101-1030 | S.H.C.S. 0.250-20 x 0.50 (2)119 |



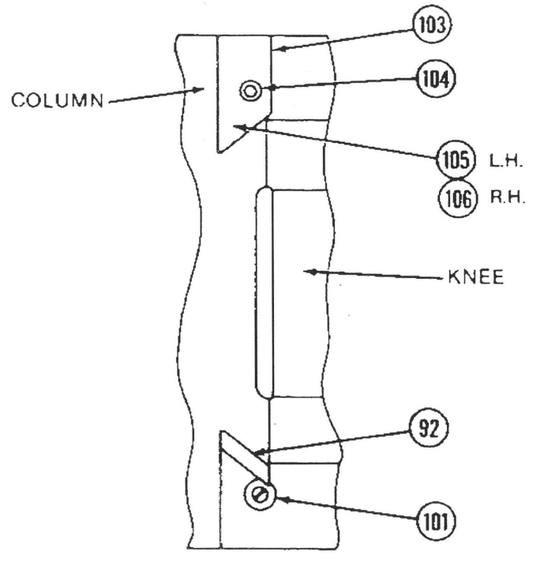

(A) Z-Axis Crank Assembly



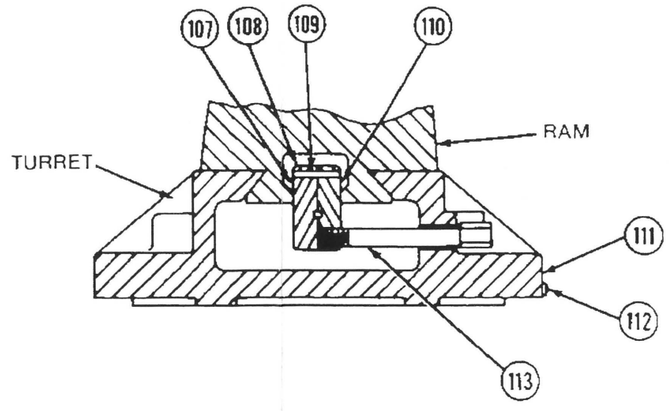

(B) Knee Gib-Lock Assembly




Y-Axis Gib Assembly



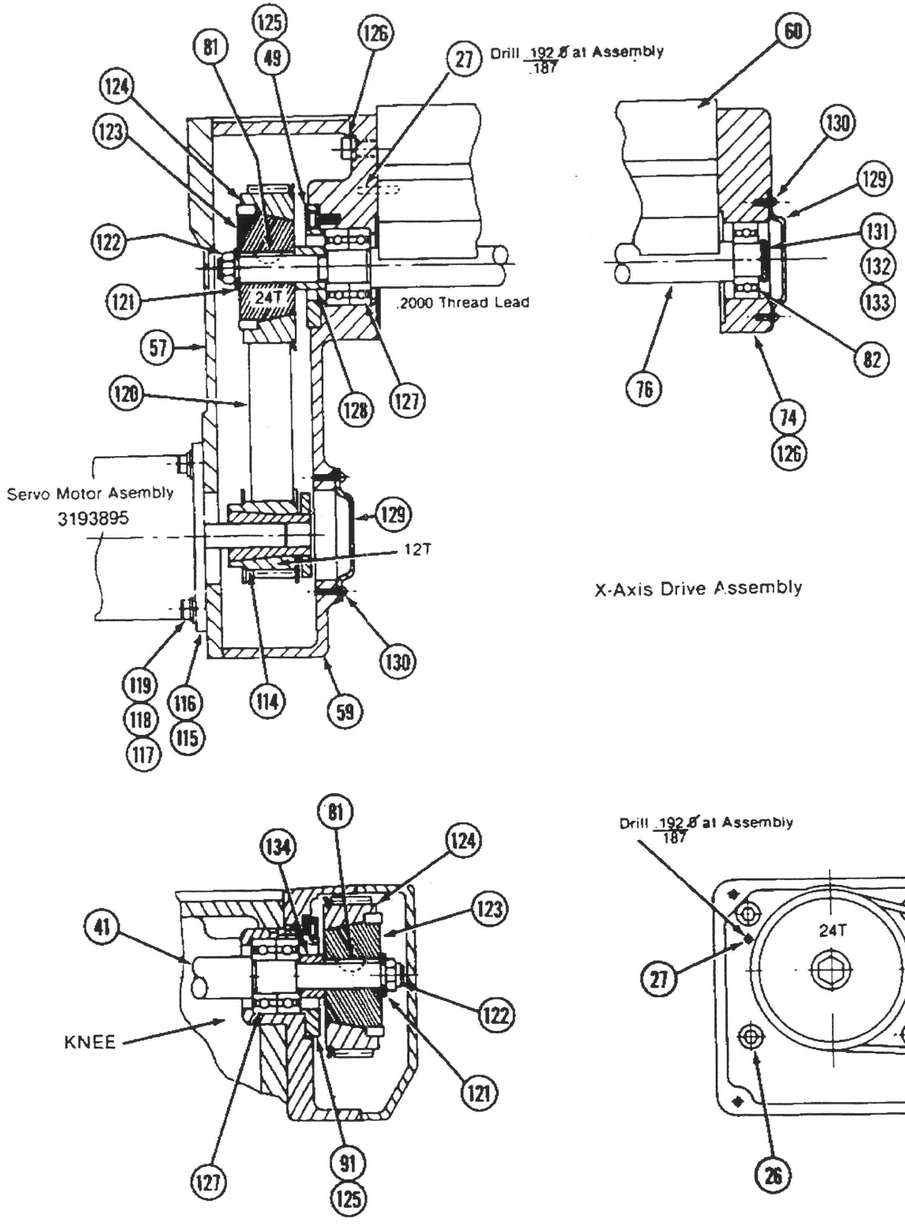

Z-Axis Gib and Wiper Assembly




Ram Lock Assembly

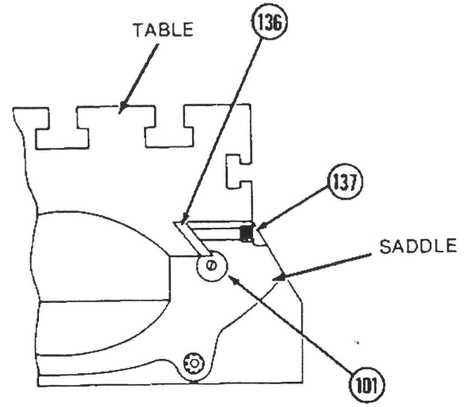
**Base Assembly - Sheet 2 of 4**

# 12. Parts Breakdown



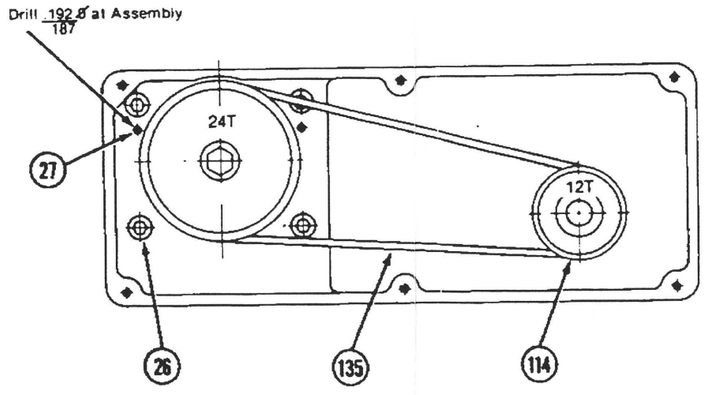

X-Axis Drive Assembly



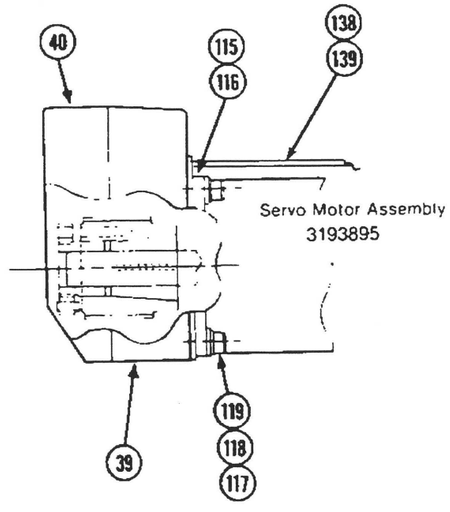




X-Axis Gib Assembly




Y-Axis Drive Assembly




**Base Assembly - Sheet 3 of 4**

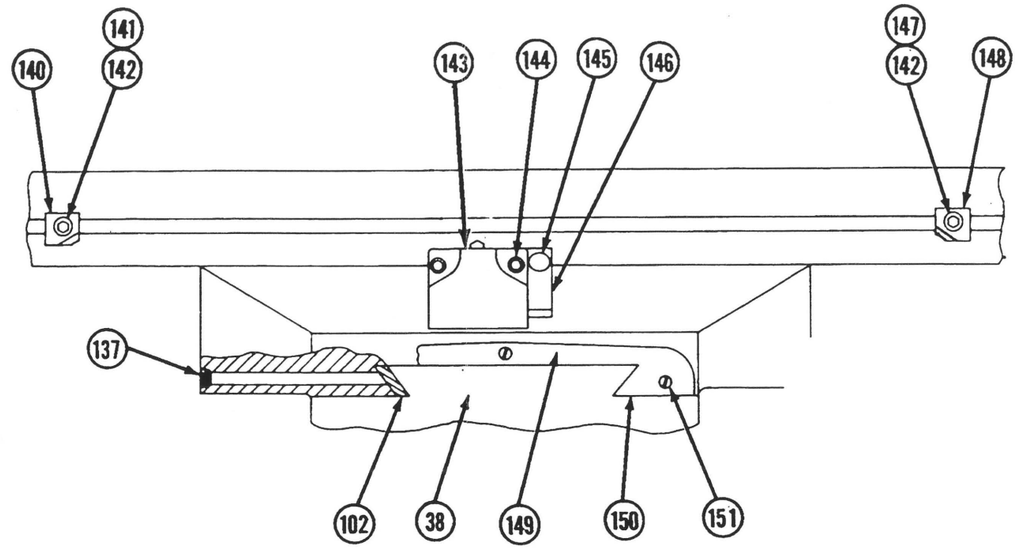
# 12. Parts Breakdown

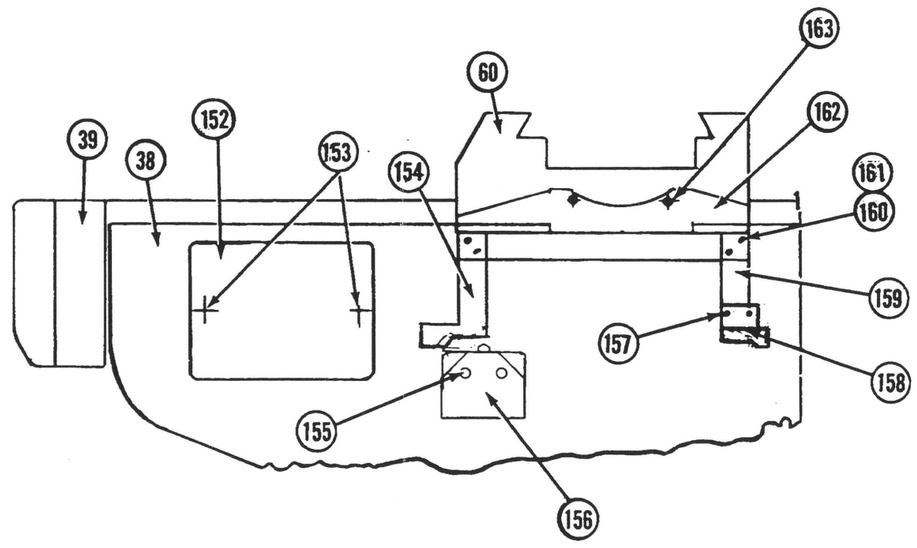
## BASE ASSEMBLY

| Item | Code No. | Description |
|---|---|---|
| 1 | 1-206-0425 | Lower Knee Lock Assembly |
| | 1-106-2179 | Handle, H-3305 |
| | 1-206-0119 | Table Lock Bolt |
| | 1-206-0423 | Lower Knee Plug |
| 2 | 1-206-9424 | Upper Knee Lock Assembly |
| | 1-106-2179 | Handle, H-3305 |
| | 1-206-0119 | Table Lock Bolt |
| | 1-206-0422 | Upper Knee Plug |
| 3 | 1-106-2834 | Nameplate |
| 4 | 1-101-1555 | Drive Screw |
| 5 | 1-274-9166 | Series I Column |
| 6 | 1-206-0208 | Turret |
| 7 | 1-106-1178 | H.H.C.S., 0.500-13 x 6.062 |
| 8 | 1-120-0109 | Washer |
| 9 | 1-206-0128 | Ram |
| 10 | 1-106-2206 | Adjustment Worm |
| 11 | 1-101-1216 | S.S.S., 10-32 x 0.187 |
| 12 | 1-206-0138 | Square Key, 0.188 x 1.938 |
| 13 | 1-206-0130 | Vertical Worm Shaft |
| 14 | 1-206-0328 | Clamping Bushing |
| 15 | 1-206-9013 | Ram Adapter |
| 16 | 1-101-1017 | S.H.C.S., 10-32 x 0.500 |
| 17 | 1-115-2094 | Spring Plunger |
| 18 | 1-206-9999 | Head Rotation Stop Pin |
| 19 | 1-265-0180 | Head Rotation Bracket |
| 20 | 1-101-1035 | S.H.C.S., 0.250-20 x 1.00 |
| 21 | 1-101-0590 | Roll Pin, 0.312 x 1.500 |
| 22 | 1-219-0178 | Head Tilting Gear |
| 23 | 1-106-0603 | Ram Adapter Scale |
| 24 | 1-198-0426 | Drive Screw #4 x 0.3 |
| 25 | 1-177-0252 | Stop Screw |
| 26 | 1-101-1074 | S.H.C.S., 0.375-16 x 1.000 |
| 27 | 1-101-0543 | Roll Pin, 0.187 x 1.000 |
| 28 | 1-101-1075 | S.H.C.S., 0.375-16 x 1.250 |
| 29 | 1-174-9049 | Shim, 0.0005 |
| 30 | 1-174-9050 | Shim, 0.001 |
| 31 | 1-174-9051 | Shim, 0.002 |
| 32 | 1-174-9052 | Shim, 0.003 |
| 33 | 1-174-9053 | Shim, 0.004 |
| 34 | 3-193-9514 | X-Axis Cover |
| 35 | 1-166-5494 | B.H.C.S., 10-32 x 0.250 |
| 36 | 1-106-0152 | Chip Guard |
| 37 | 1-106-0153 | Chip Guard |
| 38 | 1-274-9037 | Knee with Chrome |
| 39 | 1-274-9001 | Y-Axis Bracket |
| 40 | 1-274-9002 | Y-Axis Bracket Cover |
| 41 | 1-174-9020 | Y-Axis Ballscrew (0.200 in. Lead) |
| 42 | 1-274-9023 | Ballscrew Bracket |
| 43 | 1-101-1755 | Hex Jam Nut, 5-20 |
| 44 | 1-206-0072 | Knee Elevating Washer |
| 45 | 1-206-0071 | Key Square, 0.1875 |
| 46 | 1-106-2204 | Bevel Gear |
| 47 | 1-106-0205 | Bearing |
| 48 | 1-206-0070 | Bearing Retainer |
| 49 | 1-101-1031 | S.H.C.S., 0.250-20 x 0.625 |
| 50 | 1-206-0069 | Z-Axis Leadscrew |
| 51 | 1-206-0051 | Z-Axis Screw Nut |
| 52 | 1-101-1195 | B.H.C.S., 0.250-20 x 1.000 |
| 53 | 1-206-0207 | Pedestal |
| 54 | 1-101-1074 | S.H.C.S., 0.375-16 x 1.000 |
| 55 | 1-274-1380 | Saddle with Chrome |
| 56 | 1-206-0489 | Saddle Lubricating Kit (Sect. 6.1) |
| | 1-141-3235 | Drive Bushing (6) |
| | 1-141-3230 | Bracket |
| | 1-141-3236 | Tubing Clip (2) |
| | 1-141-0052 | 10-Way Junction Assembly |
| | 1-141-0063 | Junction |
| | 1-141-3219 | Compression Nut (8) |
| | 1-141-3221 | Compression Sleeve |
| | 1-141-3225 | Nylon Tubing, 0.156 OD (9 ft.) |
| | 1-141-3211 | Metering Unit (5) |
| | 1-141-3210 | Meter Unit (3) |
| | 1-141-3226 | Closure Plug |
| | 1-141-3220 | Compression Bushing |
| | 1-141-3224 | Brass Tubing, 0.156 OD (0.417 ft.) |
| | 1-141-3293 | Compression Sleeve |
| 57 | 1-274-9004 | X-Axis Bracket Cover |
| 58 | 1-101-1031 | S.H.C.S., 0.250-20 x 0.625 |
| 59 | 1-274-9003 | X-Axis Bracket |
| 60 | 1-206-0346 | 42 in. Table |
| 61 | 1-206-0255 | Ram Pinion |
| 62 | 1-206-1028 | Adapter Pivot Pin |
| 63 | 1-206-0140 | Ram Pinion Screw |
| 64 | 1-106-0892 | Retaining Ring (2) |
| 65 | 1-120-0109 | Washer |
| 66 | 1-106-1180 | H.H.C.S., 0.500-13 x 7.25 |
| 67 | 1-101-1552 | Drive Screw |
| 68 | 1-119-2856 | Ram Adapter Warning Plate |
| 69 | 1-101-1555 | Drive Screw |
| 70 | 1-106-2826 | Angle Plate |
| 71 | 1-106-0602 | Ram Scale |
| 72 | 1-198-0426 | Drive Screw 3 4x.3 |
| 73 | 1-206-0144 | Turret Miller Spider |
| 74 | 1-274-9015 | Table End Bracket |
| 75 | 1-174-9030 | Cover |
| 76 | 1-174-9019 | X-Axis Ballscrew (0.200 in. Lead) |
| 77 | 1-101-1041 | S.H.C.S., 0.250-20 x 1.625 |
| 78 | 1-101-1034 | S.H.C.S., 0.250-20 x 0.875 |
| 79 | 1-106-2205 | Pinion Gear |
| 80 | 1-101-1220 | S.S.S., 0.250-20 x 0.250 |

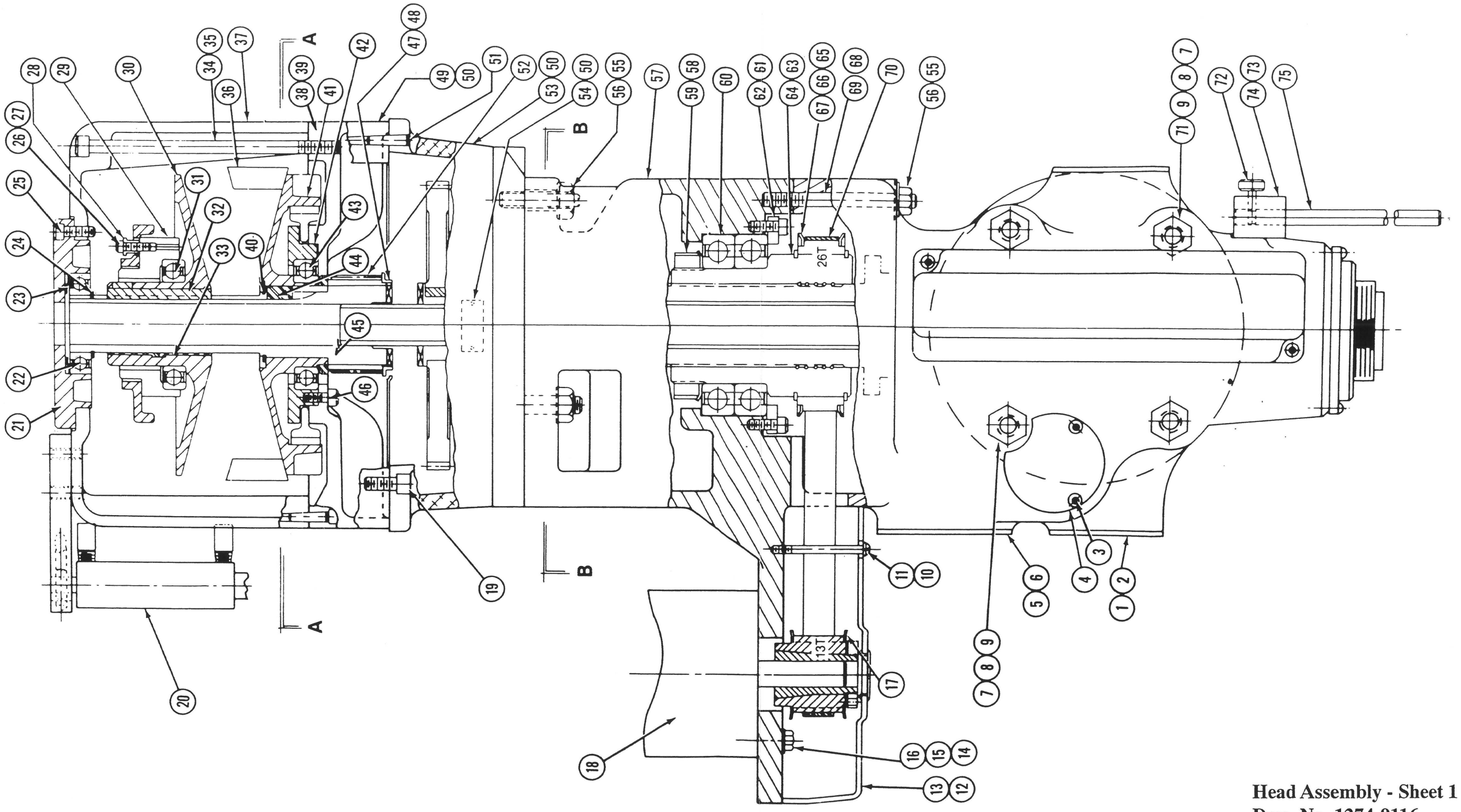
## BASE ASSEMBLY

| Item | Code No. | Description |
|---|---|---|
| 81 | 1-101-3078 | #7 Woodruff Key |
| 82 | 1-106-0204 | Bearing (2) |
| 83 | 1-206-0147 | Gear Shaft |
| 84 | 1-165-0895 | Retaining Ring |
| 85 | 1-206-0210 | Bearing Retainer |
| 86 | 1-206-0077 | Dial Holder |
| 87 | 1-206-0078 | Knurled Dial Locknut |
| 88 | 1-206-1249 | Knee Crank Assembly |
| 89 | 1-206-0079 | Clutch Sleeve |
| 90 | 1-206-0076 | Z-Axis Inch Dial |
| 91 | 1-101-1030 | S.H.C.S., 0.250-20 x 0.500 |
| 92 | 1-206-0146 | Knee to Column Gib |
| 93 | 1-206-0148 | Knee Locking Camshaft |
| 94 | 1-101-0409 | Taper Pin #1 x 1.000 |
| 95 | 1-206-0091 | Cam Shaft Hub |
| 96 | 1-206-0092 | Knee Locking Handle |
| 97 | 1-206-0089 | Knee Lock Plunger |
| 98 | 1-101-1375 | S.S.S., 0.312-18 x 0.312 |
| 99 | 1-101-1270 | S.S.S., Knurled 0.312-18 x 0.312 |
| 100 | 1-101-0786 | Knee Gib Lock Pin Plug |
| 101 | 1-106-0088 | Gib Adjustment Screw |
| 102 | 1-206-0124 | Saddle to Knee Gib |
| 103 | 1-106-2405 | Felt Wiper (2) |
| 104 | 1-101-1031 | S.H.C.S., 0.250-20 x 0.625 |
| 105 | 1-106-0093 | Left Side Wiper Holder |
| 106 | 1-106-0094 | Right Side Wiper Holder |
| 107 | 1-206-0141 | Untapped Ram Clamp |
| 108 | 1-206-0137 | Ram Clamp Bar |
| 109 | 1-101-0770 | Rivet Pin |
| 110 | 1-206-0136 | Tapped Ram Clamp |
| 111 | 1-115-2802 | Positioning Plate |
| 112 | 1-101-1555 | Drive Screw |
| 113 | 1-106-0112 | Ram Lock Stud (2) |
| 114 | 1-278-0466 | Adjustable Motor Assembly |
| | 1-101-1207 | S.S.S., 8-32 x 0.250 |
| | 1-178-0468 | Timing Pulley, 12T |
| | 1-178-0511 | S.S.S., 0.250-28 x 0.37 |
| | 1-278-0467 | Timing Collar |
| | 1-278-0469 | Timing Bushing |
| 115 | 1-274-9041 | Motor Mounting Adapter (2) |
| 116 | 1-101-0173 | F.H.C.S., 0.312-24 x 0.562 Set |
| 117 | 1-142-1984 | Washer, 0.343 (8) |
| 118 | 1-101-1050 | S.H.C.S., 0.312-18 x 0.500 (8) |
| 119 | 1-119-1965 | External Lock Washer, 0.312 Set |
| 120 | 1-165-2116 | Timing Special Belt |
| 121 | 1-177-0151 | Flat Washer, 1.125 x 531 x 0.187 |
| 122 | 1-101-0301 | Locknut (2) |
| 123 | 1-174-9044 | Taper Lock Bushing (2) |
| 124 | 1-174-9043 | Timing Pulley (24T) (2) |
| 125 | 1-206-0075 | Bearing Retainer Ring (2) |
| 126 | 1-101-1076 | S.H.C.S., 0.375-16 x 1.500 |
| 127 | 1-106-0203 | Bearing (2) |
| 128 | 1-274-9027 | X-Axis Bearing Spacer |
| 129 | 1-278-0491 | Motor Pulley Access Cover (2) |
| 130 | 1-166-5162 | B.H.C.S., 10-32 x 0.375 |
| 131 | 1-166-5280 | #222 Loctite |
| 132 | 1-101-1130 | F.H.C.S., 10-32 x 0.500 |
| 133 | 1-274-9024 | X-Axis Bearing Plate |
| 134 | 1-274-9028 | Y-Axis Bearing Spacer |
| 135 | 1-165-2113 | Timing Belt |
| 136 | 1-206-0482 | Table/Saddle Gib Chrome |
| 137 | 1-101-1250 | S.S.S., 0.500-13 x 0.375 |
| 138 | 1-274-9139 | Splash Cover |
| 139 | 1-101-1001 | S.H.C.S., 6-32 x 0.250 |
| 140 | 1-274-9149 | X-Axis Trip Dog Bracket |
| 141 | 1-171-1085 | S.H.C.S., 0.375-16 x 3.250 |
| 142 | 1-215-0321 | Tee Nut Stop Dog (2) |
| 143 | 3-193-9257 | X-Axis Cable Assembly |
| 144 | 1-101-1191 | B.H.C.S., 10-32 x 0.625 |
| 145 | 1-101-1072 | S.H.C.S., 0.375-16 x 0.875 |
| 146 | 1-274-9006 | X-Axis Mounting Block |
| 147 | 1-101-1082 | S.H.C.S., 0.375-16 x 2.750 |
| 148 | 1-274-9018 | X-Axis Trip Dog Bracket |
| 149 | 1-206-0123 | Knee Wiper Plate (2) |
| 150 | 1-106-2406 | Felt Wiper (4) |
| 151 | 1-101-1580 | O.H.M.S., 10-32 x 0.500 |
| 152 | 1-211-0069 | Knee Access Cover |
| 153 | 1-198-0449 | B.H.C.S., 0.250-20 x 0.375 |
| 154 | 1-274-9145 | Y-Axis CAM |
| 155 | 1-101-1033 | S.H.C.S., 0.250-20 x 0.75 |
| 156 | 3-193-9258 | Y-Axis Cable Assembly |
| 157 | 1-101-1010 | S.H.C.S. 10-24 x 0.50 |
| 158 | 1-274-0049 | Y-Axis CAM (Home Position) |
| 159 | 1-274-0048 | Y-Axis CAM (Forward Position) |
| 160 | 1-101-1010 | S.H.C.S. 10-24 x 0.50 |
| 161 | 1-117-1900 | Washer, #10 Flat (2) |
| 162 | 1-274-9146 | Bracket, Trip Dog |
| 163 | 1-101-1030 | S.H.C.S. 0.250-20 x 0.50 (2)119 |




**Base Assembly - Sheet 4 of 4**
**X- and Y-Axis Limit Switches**



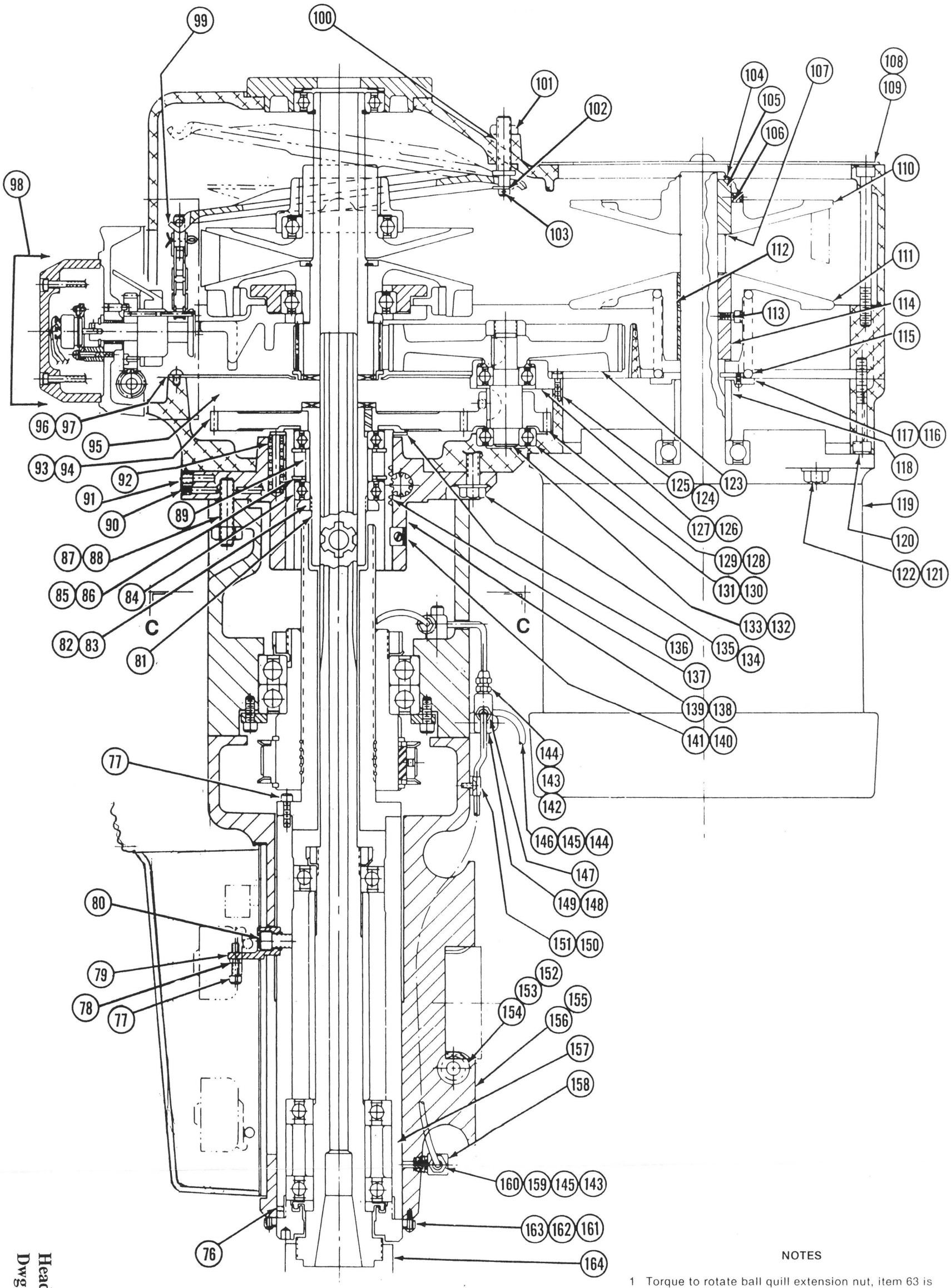

**Head Assembly - Sheet 1 of 3**
**Dwg. No. 1274-9116**

## HEAD ASSEMBLY — Dwg. 1274-9116

| Item | Code No. | Description |
|---|---|---|
| 1 | 1-101-1010 | S.H.C.S., 10-24 x 0.500 (4) |
| 2 | 1-265-5208 | Clutch Arm Hole Cover (2) |
| 3 | 1-265-5209 | Feed Trip Bracket Cover |
| 4 | 1-101-1028 | S.H.C.S., 0.250-20 x 0.375 (2) |
| 5 | 1-165-5210 | Gear Box Cover |
| 6 | 1-101-1445 | R.H.M.S., 10-24 x 0.375 (4) |
| 7 | 1-219-1620 | T-Bolt, 0.500-13 (4) |
| 8 | 1-120-0109 | Washer (4) |
| 9 | 1-101-1728 | Hex Nut, 0.5-13 (4) |
| 10 | 1-177-0083 | R.H.M.S., 10-32 x 2.25 (3) |
| 11 | 1-117-1900 | #10 Flat Washer (3) |
| 12 | 1-277-0140 | Z-Axis Drive Motor Cover |
| 14 | 1-101-1143 | H.H.C.S., 0.312-18 x 1.000 (4) |
| 15 | 1-165-1909 | Flat Washer, 0.328 (4) |
| 16 | 1-119-1965 | Lock Washer, 0.312 (External) (4) |
| 17 | 1-278-0472 | Adjustable Motor Assembly |
| | 1-101-1207 | S.S.S., 8-32 x 0.250 |
| | 1-178-0471 | Special Pulley (13 Teeth) |
| | 1-278-0473 | Motor Pulley Flange |
| | 1-178-0511 | S.S.S., 0.250-28 x 0.375 (3) |
| | 1-278-0467 | Timing Pulley Collar |
| | 1-278-0470 | Taper Sheave Bushing (13 Teeth) |
| | 1-278-0473 | Motor Pulley Flange |
| 18 | 3-193-8395 | Motor Assy., Servo |
| 19 | 1-101-1052 | S.H.C.S., 0.312-18 x 0.750 (2) |
| 20 | 1-265-1750 | Pneumatic Brake Assy. (Sect. 5.6) |
| 21 | 1-218-0094 | Belt Housing Top Bearing Cap |
| 22 | 1-118-0252 | Bearing |
| 23 | 1-118-1977 | Spring Washer |
| 24 | 1-118-0848 | Retaining Ring |
| 25 | 1-101-1033 | S.H.C.S., 0.250-20 x 0.750 (3) |
| 26 | 1-101-1020 | S.H.C.S., 10-32 x 0.750 (2) |
| 27 | 1-166-5819 | #242 Locktite |
| 28 | 1-218-0089 | Pivot Sleeve (2) |
| 29 | 1-218-0056 | Varidisc Housing Bearing |
| 30 | 1-218-0081 | Adjustable Driven Varidisc |
| 31 | 1-117-0262 | Bearing |
| 32 | 1-118-2122 | Flat Plastic Key |
| 33 | 1-118-2124 | Adjustable Varidisc Bearing (2) |
| 34 | 1-101-1065 | S.H.C.S., 0.312-18 x 4.0 (3) |
| 35 | 1-101-1069 | S.H.C.S., 0.312-18 x 6.0 (2) |
| 36 | 1-118-2120 | Variable Speed Belt |
| 37 | 1-277-0128 | Upper Belt Housing |
| 38 | 1-277-0125 | Belt Housing Base |
| 39 | 1-118-0107 | Taper Pin, #4 x 1.0 (2) |
| 40 | 1-118-0855 | Snap Ring |
| 41 | 1-218-0082 | Stationary Driven Varidisc |
| 42 | 1-218-0057 | Bearing Brake Cap |
| 43 | 1-117-0262 | Bearing |
| 44 | 1-218-0084 | Key Square, 0.312 x 0.562 |
| 45 | 1-218-0078 | Spindle Pulley Spacer |
| 46 | 1-101-1034 | S.H.C.S., 0.250-20 x 0.875 (2) |
| 47 | 1-255-0012 | Spindle Pulley Hub |
| 48 | 1-218-0064 | Clutch Sleeve |
| 49 | 1-118-2897 | 2J Lube Nameplate |
| 50 | 1-101-1552 | Drive Screw (8) |
| 51 | 1-118-0107 | Taper Pin, #4 x 1.000 (2) |
| 52 | 1-155-2106 | Timing Belt |
| 53 | 1-118-2893 | 2J Head Hi-Lo Speed Ring |
| 54 | 1-119-2879 | J-Head Nameplate |
| 55 | 1-101-1720 | Hex Nut, 0.375-16 (6) |
| 56 | 1-120-0109 | Washer (6) |
| 57 | 1-274-9025 | Drive Motor Bracket |
| 58 | 1-177-0149 | Locknut |
| 59 | 1-177-0150 | Bearing Lock Washer |
| 60 | 1-177-0118 | Bearing |
| 61 | 1-277-0103 | Bearing Retainer |
| 62 | 1-101-1033 | S.H.C.S.,0 250-20 x 0.750 (5) |
| 63 | 1-177-0100 | Z-Axis Ball Quill Assembly |
| 64 | 1-101-0879 | Retaining Ring (2) |
| 65 | 1-277-0200 | Key Square, 0.188 x 0.875 |
| 66 | 1-101-1215 | S.S.S., 10-32 x 0.250 |
| 67 | 1-177-0181 | Pulley Timing (26T) |
| 68 | 1-218-0085 | Stud (3) |
| 69 | 1-101-0195 | #271 Loctite |
| 70 | 1-180-0012 | Timing Belt |
| 71 | 1-219-0135 | Lower Clamping Spacer (2) |
| 72 | 1-220-0102 | Thumb Screw |
| 73 | 1-277-0217 | Torque Rod Block |
| 74 | 1-101-1036 | S.H.C.S., 0.250-20 x 1.125 (2) |
| 75 | 1-277-0218 | Torque Rod |
| 76 | 1-101-1265 | S.S.S., 0.250-20 x 0.250 Knurled |
| 77 | 1-101-1022 | S.H.C.S., 10-32 x 1.000 (7) |
| 78 | 1-101-1705 | Hex Nut, 10-32 |
| 79 | 1-277-0115 | Limit Switch Trip Dog |
| 80 | 1-101-1090 | S.H.C.S., 0.375-24 x 0.625 |
| 81 | 1-218-0111 | Splined Gear Hub |
| 82 | 1-118-1794 | Bearing Locknut |
| 83 | 1-166-5819 | #242 Loctite |
| 84 | 1-118-0254 | Bearing (2) |
| 85 | 1-118-1977 | Spring Washer |
| 86 | 1-118-0803 | Retaining Ring (2) |
| 87 | 1-277-0110 | Mounting Stud (3) |
| 88 | 1-101-0195 | #271 Loctite |
| 89 | 1-218-0063 | Bull Gear Bearing Spacer |
| 90 | 1-101-1232 | S.S.S., 0.250-28 x 0.250 |
| 91 | 1-101-1247 | S.S.S., 0.312-24 x 0.375 |
| 92 | 1-118-2071 | Compression Spring, 0.312 x 0.540 |
| 93 | 1-218-0062 | Bull Spindle Gear |
| 94 | 1-218-0103 | Key Square, 0.312 x 0.540 |
| 95 | 1-118-3152 | Grease (11 oz.) |
| 96 | 1-177-0239 | Gear Housing Plate |
| 97 | 1-101-1445 | R.H.M.S., 10-24 x 0.375 (3) |
| 98 | 1-274-9068 | Speed Changer Assembly (PG. 5-12) |
| 99 | 1-118-0058 | Speed Changer Plate |
| 100 | 1-218-0074 | Pivot Pin |

## HEAD ASSEMBLY — Dwg. 1274-9116

| Item | Code No. | Description |
|---|---|---|
| 101 | 1-101-1745 | Hex Jam Nut, 0.375-16 |
| 102 | 1-118-0095 | Washer |
| 103 | 1-101-0604 | Cotter Pin, 0.093 x 0.625 |
| 104 | 1-101-0880 | Retaining Ring |
| 105 | 1-255-0007 | Drive Key |
| 106 | 1-101-1222 | S.S.S., 0.250-20 x 0.312 |
| 107 | 1-177-0084 | Retaining Ring |
| 108 | 1-177-0127 | Stamping Cover |
| 109 | 1-198-0457 | B.H.C.S., 0.375-16 x 0.500 (2) |
| 110 | 1-277-0082 | Stationary Motor Varidisc |
| 111 | 1-255-0046 | Adjustable Motor Varidisc |
| 112 | 1-118-2126 | Varidisc Bushing (2) |
| 113 | 1-101-1016 | S.H.C.S., 10-32 x 0.375 |
| 114 | 1-255-0004 | Varidisc Drive Key |
| 115 | 1-118-2083 | Motor Shaft Spring |
| 116 | 1-155-0003 | Spring Collar |
| 117 | 1-101-1022 | S.H.C.S., 10-32 x 1.000 (2) |
| 118 | 1-277-0143 | Pulley-Collar Motor Spacer |
| 119 | 1-177-0101 | 2HP Motor |
| 120 | 1-172-1060 | S.H.C.S., 0.312-18 x 2.250 (3) |
| 121 | 1-101-1150 | H.H.C.S., 0.375-16 x 1.250 (2) |
| 122 | 1-119-1922 | Lock Washer, 0.375 (2) |
| 123 | 1-255-0016 | Pulley Timing |
| 124 | 1-277-0126 | Gear Housing |
| 125 | 1-101-1011 | S.H.C.S., 10-24 x 0.625 (2) |
| 126 | 1-118-1975 | Spring Washer |
| 127 | 1-218-0076 | Countershaft Bearing Cap |
| 128 | 1-101-1287 | S.S.S., 0.250-20 x 0.250 Knurled |
| 129 | 1-218-0077 | Pinion Gear |
| 130 | 1-118-0235 | Bearing (2) |
| 131 | 1-101-3079 | #9 Woodruff Key (2) |
| 132 | 1-119-1738 | Hex Jam Nut, 0.625-18 |
| 133 | 1-218-0075 | Counter Shaft |
| 134 | 1-118-1906 | Flat Washer, 0.468 (3) |
| 135 | 1-177-0282 | H.H.C.S., 0.437-14 x 1.000 (3) |
| 136 | 1-118-1986 | Bull Gear Sleeve Washer |
| 137 | 1-218-0061 | Bull Gear Bearing Sleeve |
| 138 | 1-218-0054 | Clutch Fixed Bracket |
| 139 | 1-220-0154 | Oil Line Plug |
| 140 | 1-101-1548 | P.H.M.S., 10-32 x 0.375 (2) |
| 141 | 1-218-0105 | Guide (2) |
| 142 | 1-141-3210 | Meter Unit |
| 143 | 1-141-3219 | Compression Nut |
| 144 | 1-141-3221 | Compression Sleeve (3) |
| 145 | 1-141-3225 | Nylon Tubing, 0.156 OD |
| 146 | 1-141-3220 | Compression Bushing (3) |
| 147 | 1-177-0089 | Meter Nut |
| 148 | 1-101-1195 | B.H.C.S., 0.250-20 x 1.000 |
| 149 | 1-141-3212 | 3-Way Junction |
| 150 | 1-165-1199 | B.H.C.S., 10-32 x 0.500 |
| 151 | 1-141-3290 | Tube Clip,0.156 |
| 152 | 1-219-0850 | Worm Shaft |
| 153 | 1-119-2207 | Single Thread Worm Gear |
| 154 | 1-101-3077 | #5 Woodruff Key |
| 155 | 1-277-0138 | Quill Housing |
| 156 | 1-101-1370 | S.S.S., 0.250-20 x 0.375 |
| 157 | 1-277-0101 | Quill |
| 158 | 1-141-3222 | 90° Adapter Elbow |
| 159 | 1-141-3224 | Brass Tubing, 0.156 OD |
| 160 | 1-141-3293 | Compression Sleeve |
| 161 | 1-177-0172 | Felt Quill Wiper |
| 162 | 1-177-0173 | Quill Wiper Retainer |
| 163 | 1-101-1193 | B.H.C.S., 6-32 x 0.375 (4) |
| 164 | 1-277-2901 | Spdl Assy., #200 Universal |
| | 1-277-2900 | Spindle, #30 Q.C. (Sect. 5.4.1) |
| 165 | 1-118-2306 | Brake Finger (2) |
| 166 | 1-218-0069 | Brake Lock Cam |
| 167 | 1-101-1287 | S.S.S., 0.250-20 x 0.250 Knurled (2) |
| 168 | 1-218-0104 | Brake Lock Shaft Sleeve |
| 169 | 1-218-0070 | Brake Lock Shaft |
| 170 | 1-101-0535 | Roll Pin, 0.156 x 1.000 |
| 171 | 1-218-0083 | Brake Finger Pivot Stud |
| 172 | 1-118-0818 | Retaining Ring |
| 173 | 1-118-2081 | Brake Spring (2) |
| 174 | 1-218-0073 | Brake Shoe Set |
| 175 | 1-218-0071 | Brake Shoe Pivot Sleeve |
| 176 | 1-101-1138 | H.H.C.S.,0.250-20 x 0.750 |
| 177 | 1-101-0195 | #271 Loctite |
| 178 | 1-274-0030 | Spacer, Hi-Lo, W/Prg. RPM |
| 179 | 1-274-9078 | Plate, Hi-Lo Detent |
| 180 | 1-101-0085 | S.H.C.S., 10-32 x 2.750 Lg. |
| 181 | 1-218-0096 | Block, Hi-Lo Pinion |
| 182 | 1-274-9077 | Pinion, Bull Gear Shifter |
| 183 | 1-218-0100 | Plunger, Hi-Lo Detent |
| 184 | 1-118-2072 | Spr. Comp., 0.250-0.188-0.562 |
| 185 | 1-101-0516 | Pin, 0.125 x 0.625 Roll |
| 186 | 1-218-0099 | Crank, Shift, Hi-Lo |
| 187 | 1-192-2151 | Knob, Bakelite, 0.25-20 |
| 188 | 3-194-0051 | Cable Assy, Gear Select |
| 189 | 1-174-0033 | Bracket, Mtg. Prox. Sensor |
| 190 | 1-174-0034 | Bracket, Support Prox. |
| 191 | 1-178-0457 | Washer #8 Burr |
| 192 | 1-166-5676 | B.H.C.S., 8-32 x 0.375 |
| 193 | 1-118-1007 | S.H.C.S., 8-32 x 0.625 |




**Head Assembly -**
**Dwg. No. 1274-9116 Sheet 2 of 3**

NOTES

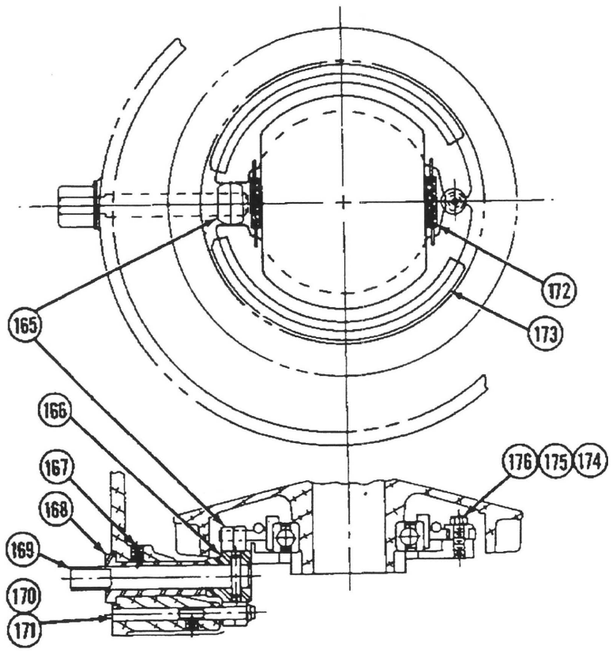
1 Torque to rotate ball quill extension nut, item 63 is 13.4 oz-in. maximum when extending the quill and 19.1 oz-in. maximum when retracting the quill. This is equal to a 28 oz. pull on drive belt (item 70) extending the quill and a 40 oz. maximum pull retracting the quill.

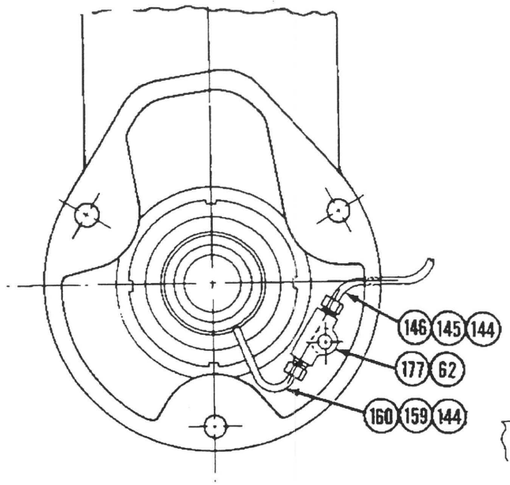
2 Bend copper tube as shown in side view to direct oil into ball quill extension (item 63).

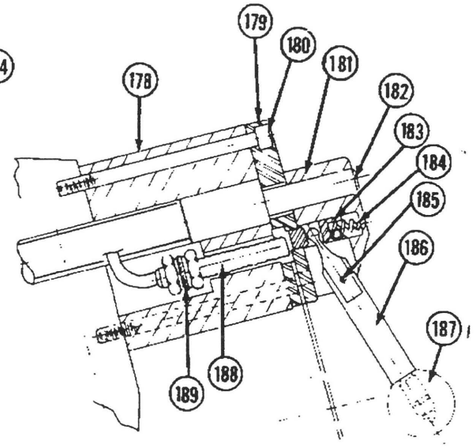
3 Adjust quill feed drive belt (item 70) to 66 lbs. tension = 1/8 in. deflection with 5 lb. force applied.

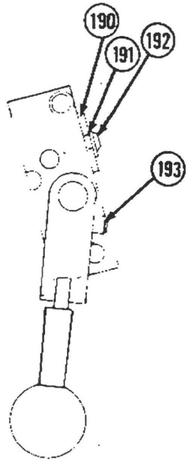
4 Ball quill extension assembly, inspection and cleaning — Spec. Dwg. 1-277-0240, 1-277-0241, 1-277-0242.

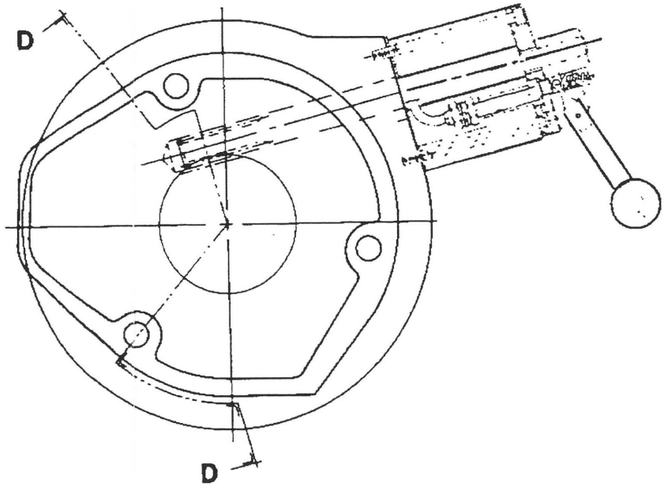
5 Quill down feed limit switch setting — Spec. Dwg. 1-274-9026.



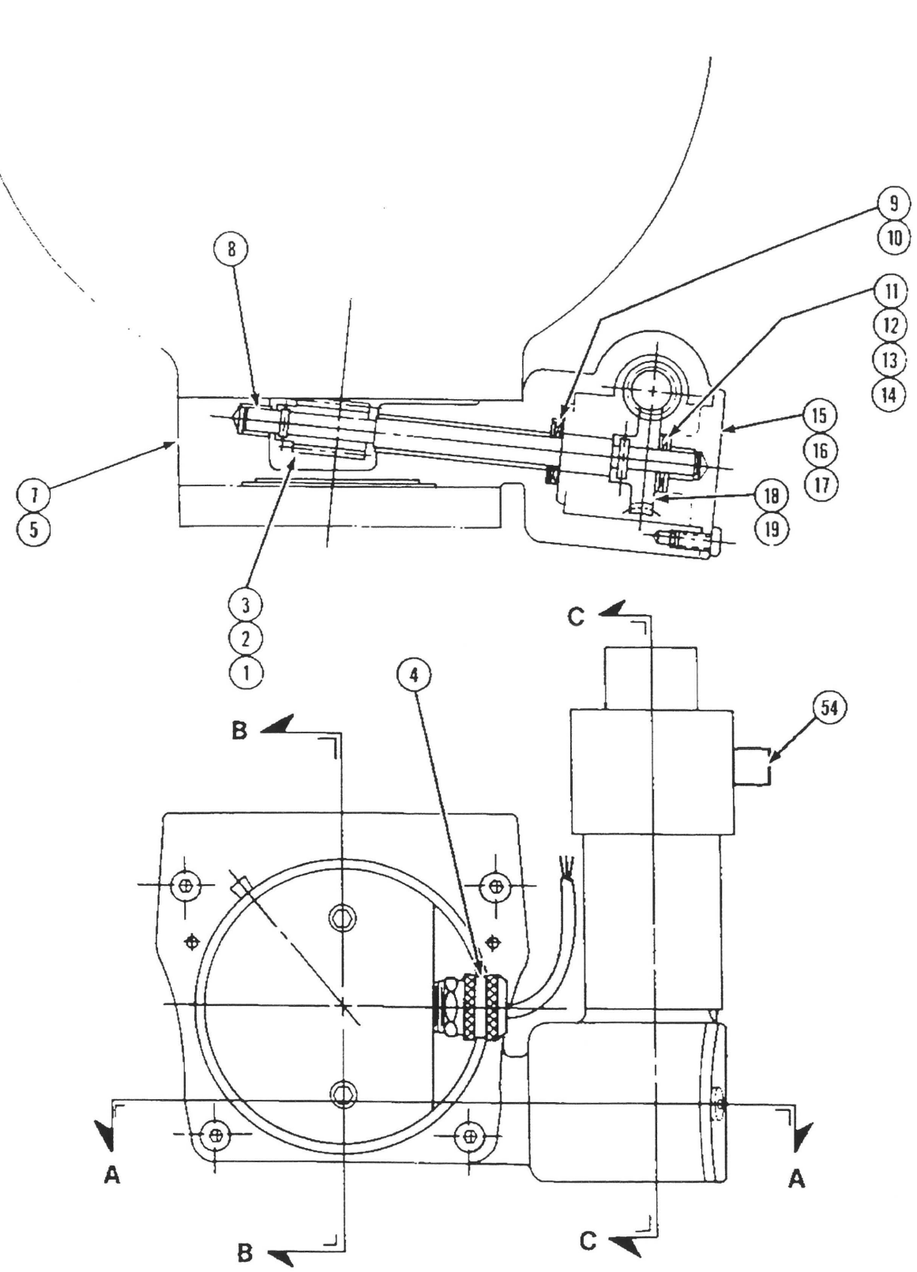

**Head Assembly - Sheet 3 of 3**

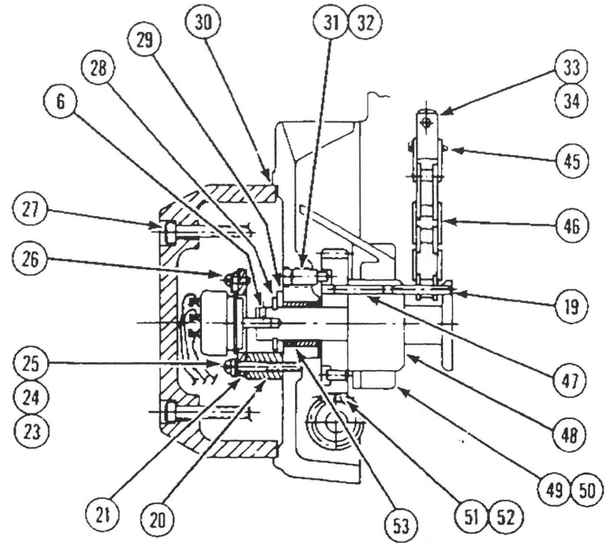
## HEAD ASSEMBLY — Dwg. 1274-9116

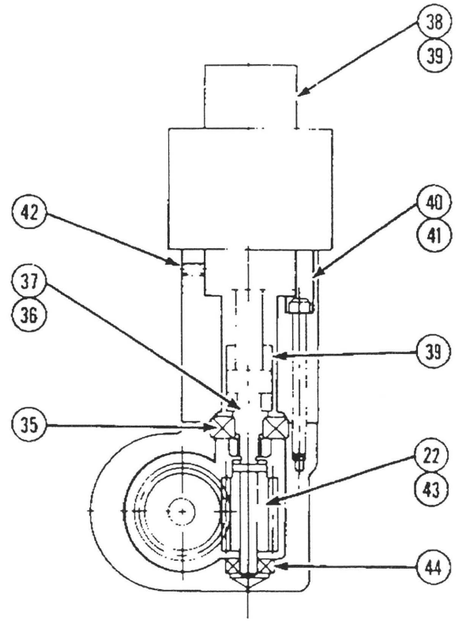
| Item | Code No. | Description |
|---|---|---|
| 101 | 1-101-1745 | Hex Jam Nut, 0.375-16 |
| 102 | 1-118-0095 | Washer |
| 103 | 1-101-0604 | Cotter Pin, 0.093 x 0.625 |
| 104 | 1-101-0880 | Retaining Ring |
| 105 | 1-255-0007 | Drive Key |
| 106 | 1-101-1222 | S.S.S., 0.250-20 x 0.312 |
| 107 | 1-177-0084 | Retaining Ring |
| 108 | 1-177-0127 | Stamping Cover |
| 109 | 1-198-0457 | B.H.C.S., 0.375-16 x 0.500 (2) |
| 110 | 1-277-0082 | Stationary Motor Varidisc |
| 111 | 1-255-0046 | Adjustable Motor Varidisc |
| 112 | 1-118-2126 | Varidisc Bushing (2) |
| 113 | 1-101-1016 | S.H.C.S., 10-32 x 0.375 |
| 114 | 1-255-0004 | Varidisc Drive Key |
| 115 | 1-118-2083 | Motor Shaft Spring |
| 116 | 1-155-0003 | Spring Collar |
| 117 | 1-101-1022 | S.H.C.S., 10-32 x 1.000 (2) |
| 118 | 1-277-0143 | Pulley-Collar Motor Spacer |
| 119 | 1-177-0101 | 2HP Motor |
| 120 | 1-172-1060 | S.H.C.S., 0.312-18 x 2.250 (3) |
| 121 | 1-101-1150 | H.H.C.S., 0.375-16 x 1.250 (2) |
| 122 | 1-119-1922 | Lock Washer, 0.375 (2) |
| 123 | 1-255-0016 | Pulley Timing |
| 124 | 1-277-0126 | Gear Housing |
| 125 | 1-101-1011 | S.H.C.S., 10-24 x 0.625 (2) |
| 126 | 1-118-1975 | Spring Washer |
| 127 | 1-218-0076 | Countershaft Bearing Cap |
| 128 | 1-101-1287 | S.S.S., 0.250-20 x 0.250 Knurled |
| 129 | 1-218-0077 | Pinion Gear |
| 130 | 1-118-0235 | Bearing (2) |
| 131 | 1-101-3079 | #9 Woodruff Key (2) |
| 132 | 1-119-1738 | Hex Jam Nut, 0.625-18 |
| 133 | 1-218-0075 | Counter Shaft |
| 134 | 1-118-1906 | Flat Washer, 0.468 (3) |
| 135 | 1-177-0282 | H.H.C.S., 0.437-14 x 1.000 (3) |
| 136 | 1-118-1986 | Bull Gear Sleeve Washer |
| 137 | 1-218-0061 | Bull Gear Bearing Sleeve |
| 138 | 1-218-0054 | Clutch Fixed Bracket |
| 139 | 1-220-0154 | Oil Line Plug |
| 140 | 1-101-1548 | P.H.M.S., 10-32 x 0.375 (2) |
| 141 | 1-218-0105 | Guide (2) |
| 142 | 1-141-3210 | Meter Unit |
| 143 | 1-141-3219 | Compression Nut |
| 144 | 1-141-3221 | Compression Sleeve (3) |
| 145 | 1-141-3225 | Nylon Tubing, 0.156 OD |
| 146 | 1-141-3220 | Compression Bushing (3) |
| 147 | 1-177-0089 | Meter Nut |
| 148 | 1-101-1195 | B.H.C.S., 0.250-20 x 1.000 |
| 149 | 1-141-3212 | 3-Way Junction |
| 150 | 1-165-1199 | B.H.C.S., 10-32 x 0.500 |
| 151 | 1-141-3290 | Tube Clip,0.156 |
| 152 | 1-219-0850 | Worm Shaft |
| 153 | 1-119-2207 | Single Thread Worm Gear |
| 154 | 1-101-3077 | #5 Woodruff Key |
| 155 | 1-277-0138 | Quill Housing |
| 156 | 1-101-1370 | S.S.S., 0.250-20 x 0.375 |
| 157 | 1-277-0101 | Quill |
| 158 | 1-141-3222 | 90° Adapter Elbow |
| 159 | 1-141-3224 | Brass Tubing, 0.156 OD |
| 160 | 1-141-3293 | Compression Sleeve |
| 161 | 1-177-0172 | Felt Quill Wiper |
| 162 | 1-177-0173 | Quill Wiper Retainer |
| 163 | 1-101-1193 | B.H.C.S., 6-32 x 0.375 (4) |
| 164 | 1-277-2901 | Spdl Assy., #200 Universal |
| | 1-277-2900 | Spindle, #30 Q.C. (Sect. 5.4.1) |
| 165 | 1-118-2306 | Brake Finger (2) |
| 166 | 1-218-0069 | Brake Lock Cam |
| 167 | 1-101-1287 | S.S.S., 0.250-20 x 0.250 Knurled (2) |
| 168 | 1-218-0104 | Brake Lock Shaft Sleeve |
| 169 | 1-218-0070 | Brake Lock Shaft |
| 170 | 1-101-0535 | Roll Pin, 0.156 x 1.000 |
| 171 | 1-218-0083 | Brake Finger Pivot Stud |
| 172 | 1-118-0818 | Retaining Ring |
| 173 | 1-118-2081 | Brake Spring (2) |
| 174 | 1-218-0073 | Brake Shoe Set |
| 175 | 1-218-0071 | Brake Shoe Pivot Sleeve |
| 176 | 1-101-1138 | H.H.C.S.,0.250-20 x 0.750 |
| 177 | 1-101-0195 | #271 Loctite |
| 178 | 1-274-0030 | Spacer, Hi-Lo, W/Prg. RPM |
| 179 | 1-274-9078 | Plate, Hi-Lo Detent |
| 180 | 1-101-0085 | S.H.C.S., 10-32 x 2.750 Lg. |
| 181 | 1-218-0096 | Block, Hi-Lo Pinion |
| 182 | 1-274-9077 | Pinion, Bull Gear Shifter |
| 183 | 1-218-0100 | Plunger, Hi-Lo Detent |
| 184 | 1-118-2072 | Spr. Comp., 0.250-0.188-0.562 |
| 185 | 1-101-0516 | Pin, 0.125 x 0.625 Roll |
| 186 | 1-218-0099 | Crank, Shift, Hi-Lo |
| 187 | 1-192-2151 | Knob, Bakelite, 0.25-20 |
| 188 | 3-194-0051 | Cable Assy, Gear Select |
| 189 | 1-174-0033 | Bracket, Mtg. Prox. Sensor |
| 190 | 1-174-0034 | Bracket, Support Prox. |
| 191 | 1-178-0457 | Washer #8 Burr |
| 192 | 1-166-5676 | B.H.C.S., 8-32 x 0.375 |
| 193 | 1-118-1007 | S.H.C.S., 8-32 x 0.625 |

## PNEUMATIC SPEED CHANGER — Dwg. 1-274-9068

| Item | Code No. | Description |
|---|---|---|
| 1 | 1-277-0266 | Speed Changer Shaft (1) |
| 2 | 1-101-0514 | Roll Pin, 0.125 x 0.500 (1) |
| 3 | 1-119-2208 | Boston Worm Gear (1) |
| 4 | 3-194-3439 | Spindle Speed Pot Cable (1) (includes potent. and cover) |
| 5 | 1-142-3639 | Bronze Bushing (1) |
| 6 | 1-198-9272 | S.S.S., 4-40 x 0.250 (1) |
| 7 | 1-277-0265 | Speed Changer Housing (1) |
| 8 | 1-177-0286 | Bronze Bushing (1) |
| 9 | 1-177-0267 | Outer Race (2) |
| 10 | 1-177-0268 | Bearing (1) |
| 11 | 1-177-0704 | Speed Changer Race (2) |
| 12 | 1-177-0701 | Bearing (1) |
| 13 | 1-177-0702 | Shim, 0.005 (2) |
| 14 | 1-177-0703 | Shim, 0.015 (2) |
| 15 | 1-277-0271 | End Cap (1) |
| 16 | 1-177-0272 | Bronze Bushing (1) |
| 17 | 1-101-1194 | B.H.C.S., 0.250-20 x 0.5 (3) |
| 18 | 1-277-0269 | Worm Speed Gear (20 Teeth) (1) |
| 19 | 1-101-0516 | Roll Pin, 0.125 x 0.625 (2) |
| 20 | 1-274-0052 | Spd Potentiometer Spacer (2) |
| 21 | 1-274-0051 | Speed Potentiometer Plate (1) |
| 22 | 1-277-0276 | Boston Worm Gear (1) |
| 23 | 1-166-5411 | #6 Lock Washer (2) |
| 24 | 1-166-5458 | #6 Flat Washer (2) |
| 25 | 1-166-5157 | R.H.M.S., 6-32 x 0.875 (2) |
| 26 | 1-174-0132 | Motor Mount Cleat (2) |
| 27 | 31-50-5538 | S.H.C.S., #10-32 x 1.750" (2) |
| 28 | 1-174-0078 | Retaining Ring (1) |
| 29 | 1-274-0111 | Drum Spacer (1) |
| 30 | 1-274-0060 | Cover Gasket (1) |
| 31 | 1-166-5819 | #242 Loctite |
| 32 | 1-101-1259 | S.S.S., 0.312-18 x 0.625 |
| 33 | 1-218-0066 | Chain Stud (1) |
| 34 | 1-101-0534 | Roll Pin, 0.156 x 0.875 (1) |
| 35 | 1-177-0280 | Bearing (1) |
| 36 | 1-166-5426 | Lock Nut, 0.312-24 (1) |
| 37 | 1-277-0278 | Speed Changer Shaft (1) |
| 38 | 1-177-0273 | Air Motor Cast (1) |
| 39 | 1-177-0279 | Lovejoy Coupling (1) |
| 40 | 1-277-0274 | Air Motor Mount (1) |
| 41 | 1-101-1024 | S.H.C.S., 10-32 x 2.000 (2) |
| 42 | 1-101-1260 | S.S.S., 10-32 x 0.250 (2) |
| 43 | 1-101-0506 | Roll Pin, 0.093 x 0.500 (1) |
| 44 | 1-165-0278 | Bearing (1) |
| 45 | 1-101-0620 | Cotter Pin, 0.125 x 0.750 |
| 46 | 1-118-3720 | Chain (1) |
| 47 | 1-101-0520 | Roll Pin, 0.125 x 1.000 (1) |
| 48 | 1-274-9085 | Chain Drum (1) |
| 49 | 1-218-2003 | Bearing Support Block (1) |
| 50 | 1-101-1031 | S.H.C.S., 0.250-20 x 0.625 (4) |
| 51 | 1-218-0090 | Spur Speed Gear (1) |
| 52 | 1-101-0259 | Grooved Pin, 0.187 x 0.375 (1) |
| 53 | 1-118-3646 | Bushing (1) |
| 54 | 1-101-0247 | Fitting (2) |



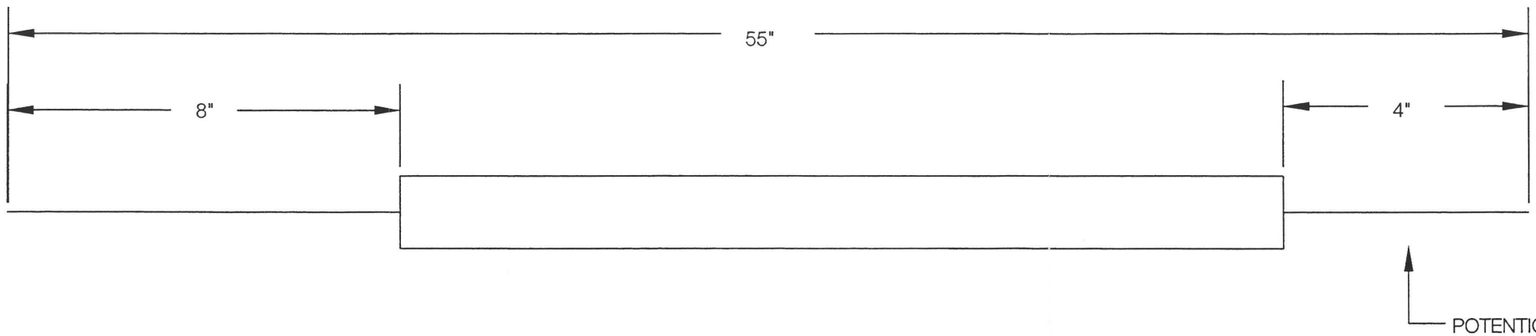




**Pneumatic Speed Changer**
**Dwg. No. 1274-9068**

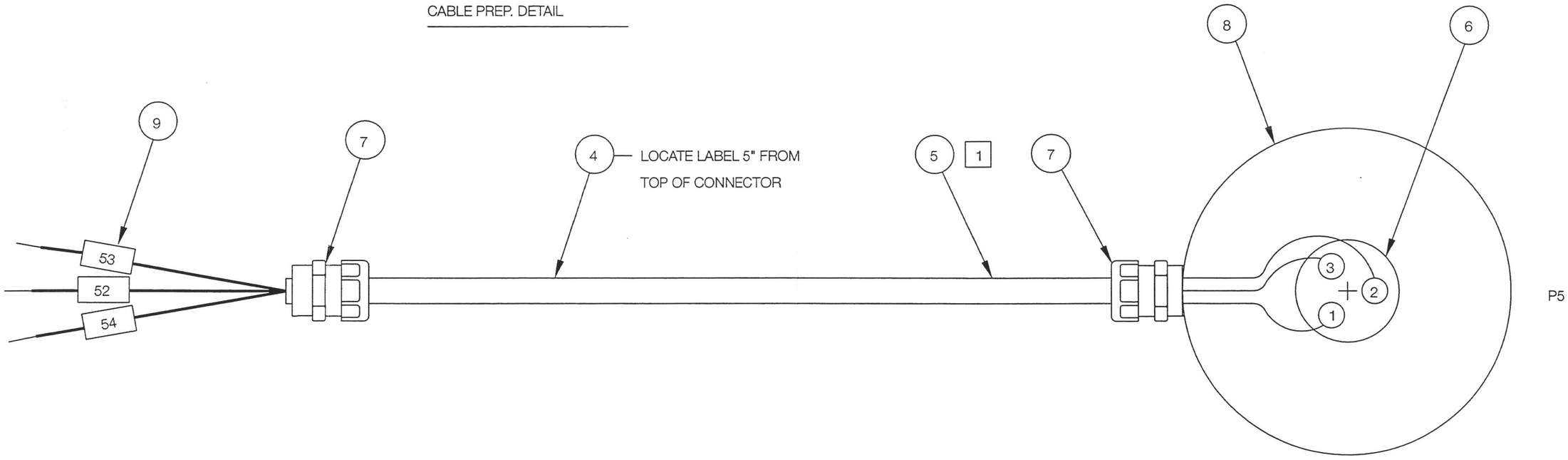
# 12. Parts Breakdown

NOTES

1 CUT GREEN WIRE OFF BOTH ENDS.




CABLE PREP. DETAIL




| WIRE TABLE | | | |
|---|---|---|---|
| COLOR | FROM | TO | WIRE # |
| RED | TB5-4 | P5-1 | 53 |
| WHT | TB5-5 | P5-2 | 52 |
| BLK | TB5-6 | P5-3 | 54 |

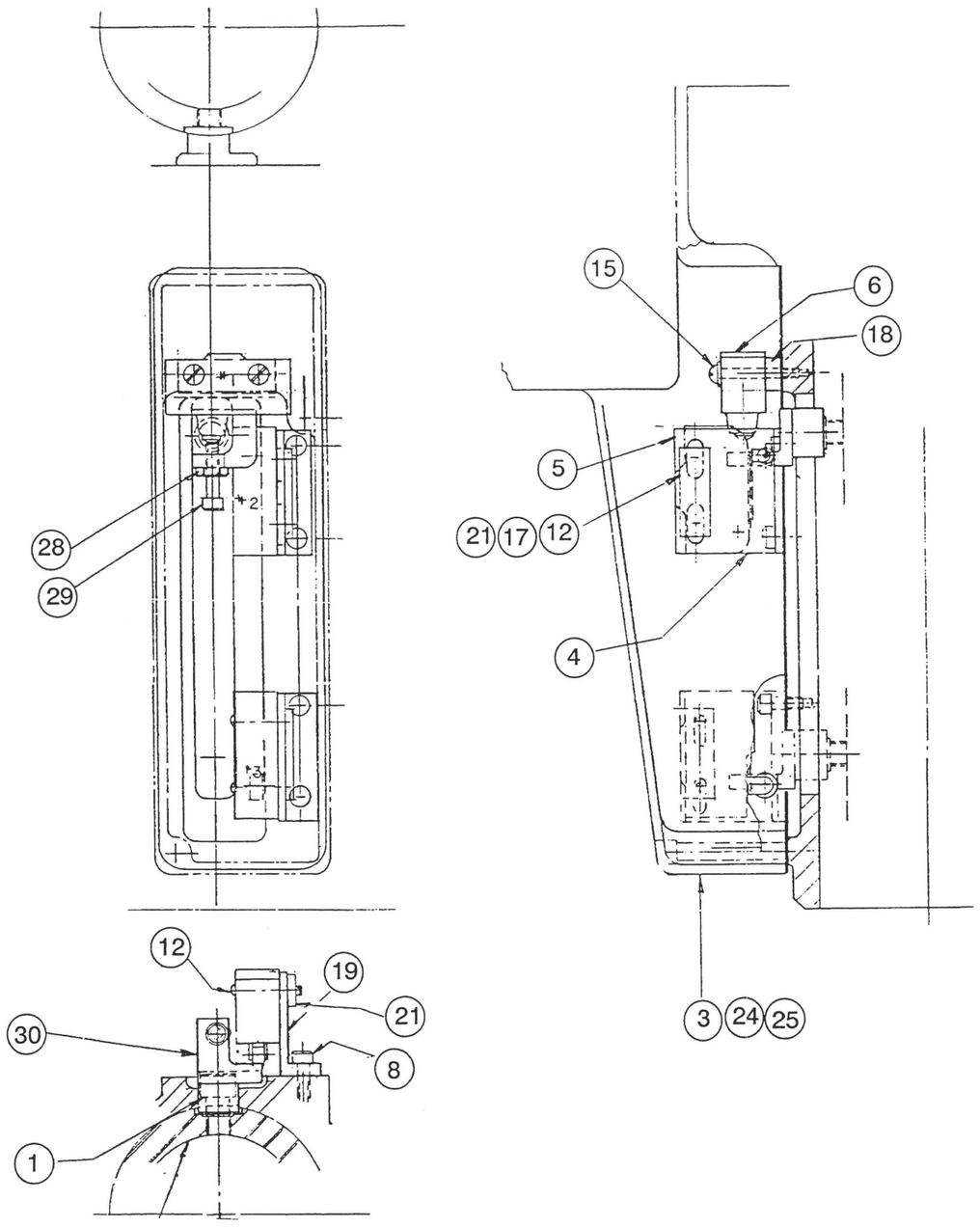
**Spindle Speed Potentiometer Cable Assy.**
**Dwg. No. 1943439**
**(For Manual Use Only)**

## SPINDLE SPEED POT CABLE ASSEMBLY — Dwg. No. 3194-3439

| Item | Code No. | Description | Qty. |
|---|---|---|---|
| 4 | 3150065 | Label, Cable Marker | 1 |
| 5 | 31509722 | Cable, 22 awg/2 pr, SHDD, TW. | 4.50 |
| 6 | 31541631 | Potentiometer, Spindle RPM | 1 |
| 7 | 31541652 | Conn. Str. .250", .120-.250 | 2 |
| 8 | 12740070 | Cover, Speed Potentiometer | 1 |
| 9 | 11010333 | Label, Wiremrkr | 6 |

## LIMIT SWITCH GROUP — Dwg. No. 1274-9026

| Item | Code No. | Description | Qty. |
|---|---|---|---|
| 1 | 12742801 | Operator Control Box | 1 |
| 3 | 11742804 | Gasket, Switch Cover | 1 |
| 4 | 11770114 | Bracket, Limit Switch | 1 |
| 5 | 11665105 | Limit Switch | 1 |
| 6 | 11665809 | Micro Limit Switch | 1 |
| 7 | 11011015 | S.H.C.S. #10-32 x .312" lg. | 4 |
| 12 | 11770121 | RHMS #6-32 x 1.000" lg. | 4 |
| 15 | 11011408 | RHMS #6-32 x 1.25" lg. | 2 |
| 16 | 11011961 | Washer, #6 Lock | 2 |
| 17 | 11665458 | Washer #6 | 2 |
| 18 | 12770116 | Spacer, Quill Pos. L SW | 1 |
| 19 | 12740174 | Bracket, Quill Down Lim. Sw. | 1 |
| 20 | 11590049 | Micro Limit Switch | 1 |
| 21 | 11480254 | Plate, Z-Switch Top Nut | 2 |
| 24 | 11011024 | S.H.C.S. #10-32 x 2.000" lg. | 1 |
| 25 | 11010085 | S.H.C.S. #10-32 x 2.750" lg. | 1 |




**LIMIT & DECELERATION SWITCH SETTING**

A. LOOSEN MOTOR PULLEY ASSEMBLY & MOVE QUILL DOWNWARD, USING BELT TO INSURE THAT SWITCH #2 IS NOT DEPRESSED.

B. WITH CONTROL ON, PRESS "EXECUTE" TO PLACE AXIS IN HOME, & MANUALLY DEPRESS SW. #2.

C. USING BELT, MOVE QUILL UPWARD TO CONTACT BUMPER.

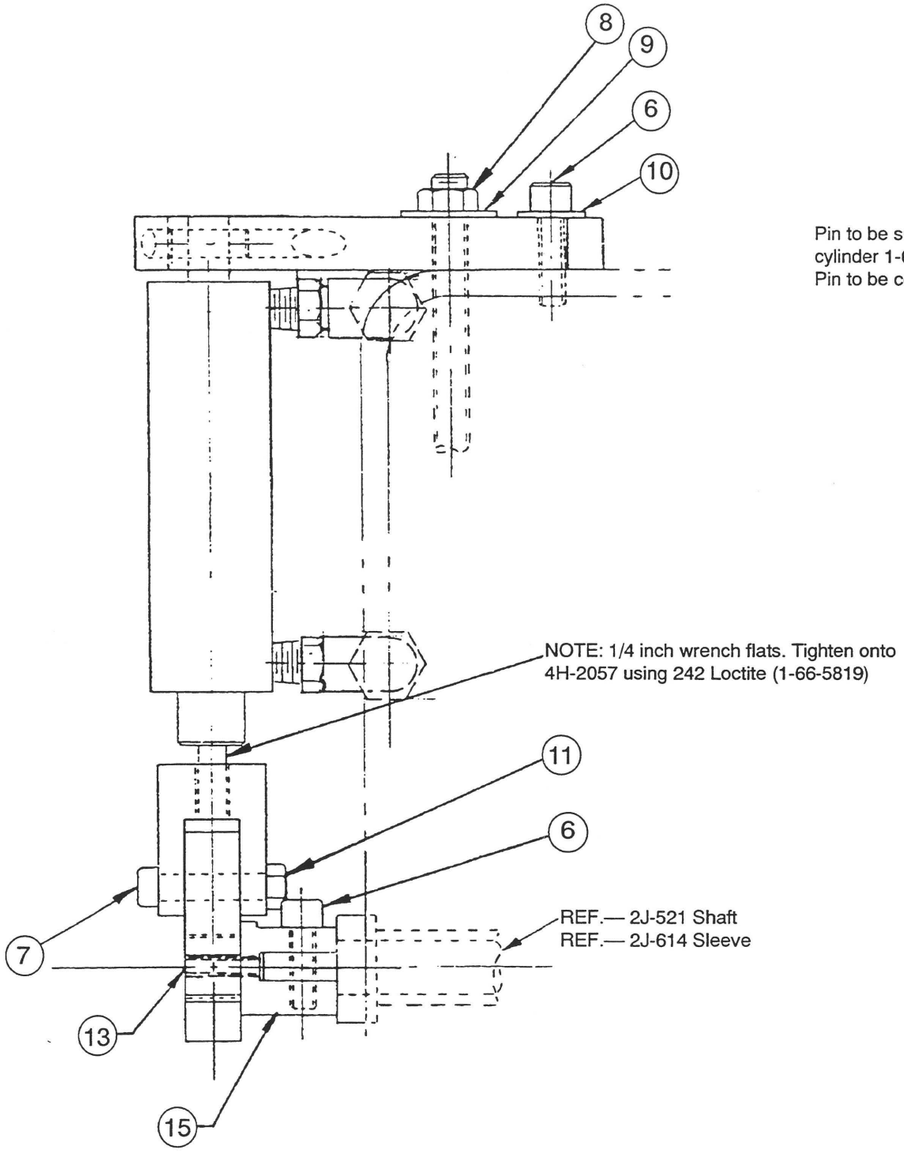
D. ROTATE PULLEY ASSEMBLY (NOT MOTOR SHAFT) ONE TURN TO MOVE QUILL DOWNWARD .100", THEN LOCK PULLEY ASSEMBLY.

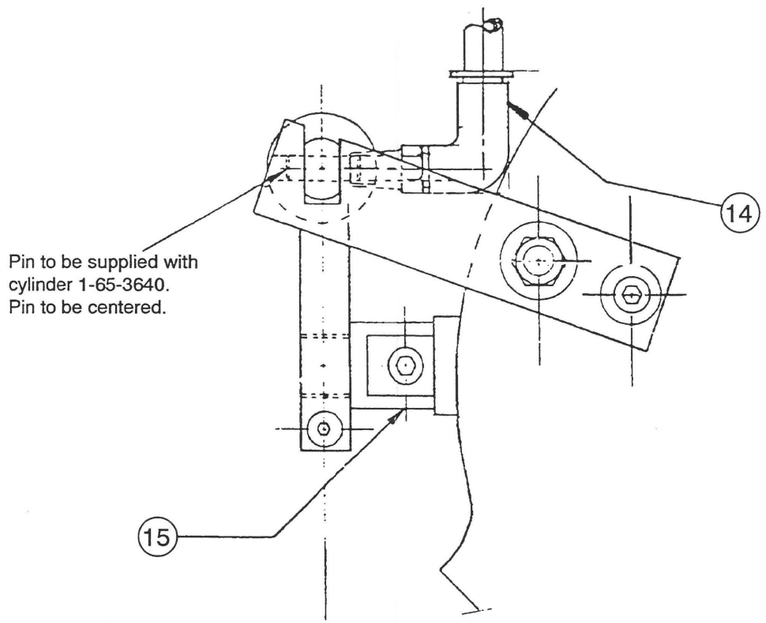
E. MOVE QUILL DOWN 0.350". USING OPERATOR'S CONTROL & SET SWITCH #2 TO ACTIVATE AT THIS POSITION.

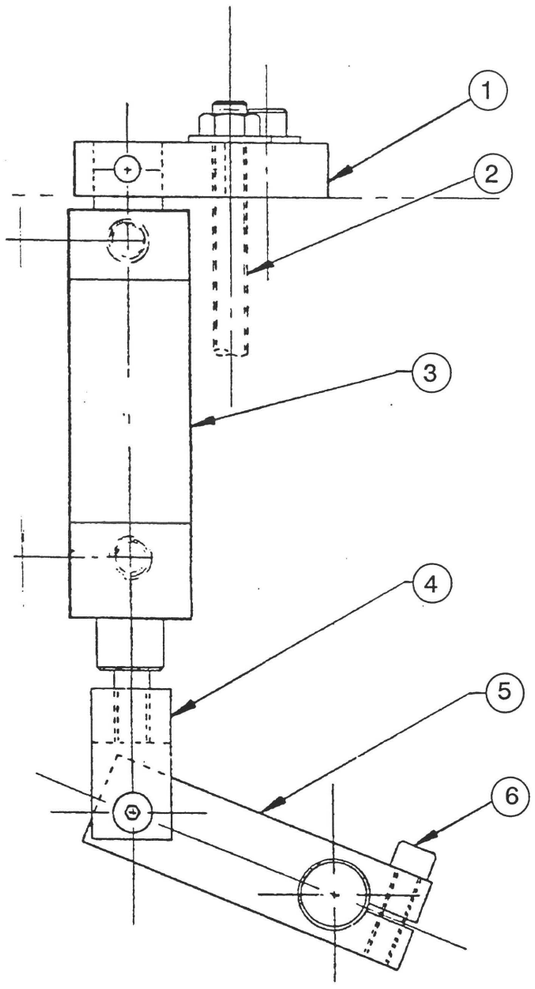
F. USE HANDWHEEL TO HOME QUILL (Z=0) AND SET LIMIT SWITCH STOP TO ACTIVATE SWITCH #1 WITH 0.025"/0.020" FEELER GAGE BETWEEN THE TWO.

G. MOVE QUILL DOWN 5.000" AND SET SWITCH #3 TO ACTIVATE WITH .025/.020 FEELER BETWEEN TRIP-DOG 77-0115 AND LIMIT SWITCH.

**Quill Limit Switch Assembly**
**Dwg. No. 74-9026 Rev. 08**
**(Manual Use Only)**



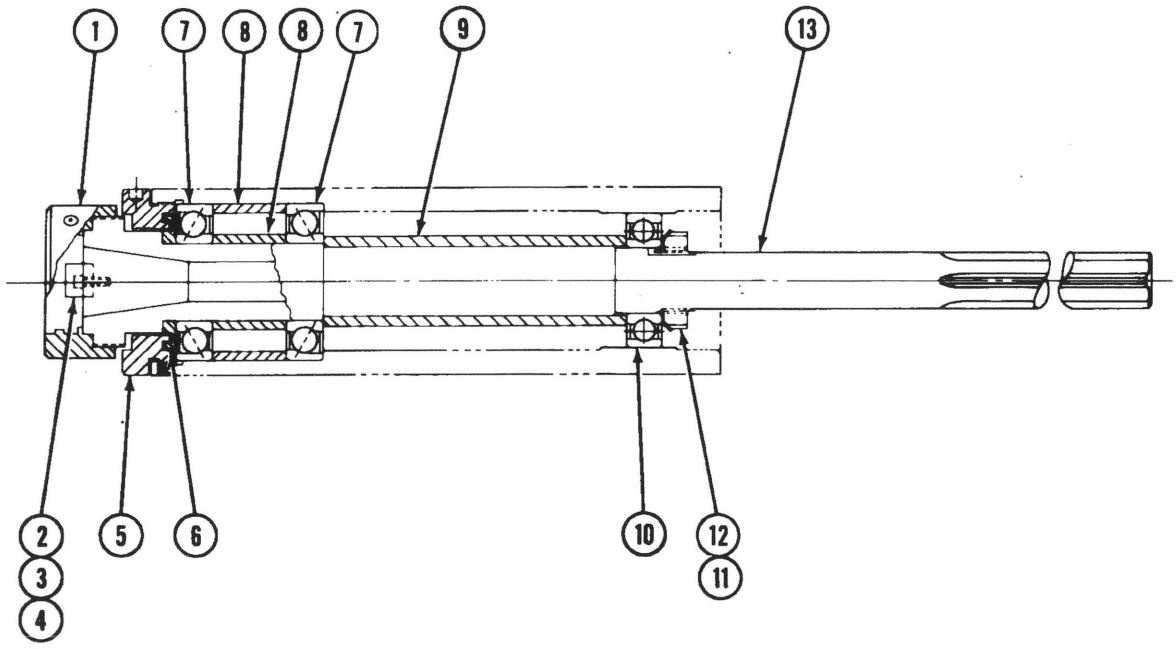

**Pneumatic Brake Assembly**
**Dwg. No. 1265-1750 Rev. 8**

## PNEUMATIC BRAKE ASSEMBLY— Dwg. 1265-1750

| Item | Code No. | Description | |
|---|---|---|---|
| 1 | 12770767 | Bracket, Cylinder, Pneu | 1 |
| 2 | 12770766 | Stud | 1 |
| 3 | 11771631 | Double Acting Cylinder | 1 |
| 4 | 12770768 | Clevis, | 1 |
| 5 | 12770757 | Lever, Pneu. Brake | 1 |
| 6 | 11011034 | SHCS, .250-20 x .875" lg | 3 |
| 7 | 11651133 | Scr, Shoulder .250 x 1.000 | 1 |
| 8 | 11011710 | Nut, Plain Hex 5/16-18 Unc | 1 |
| 9 | 11181981 | Washer .875 x .375 x .064 | 1 |
| 10 | 11111912 | Washer (SAE) Plain | 1 |
| 11 | 11651704 | Hex Nut 10-24, Self-Locking | 1 |
| 13 | 11980323 | Set Screw #8-32 x .500" | |
| 14 | 11010254 | Elbow, 90 degree, 3/8 x 1/8 NPT | 2 |
| 15 | 12770755 | Adjustment Coupling | 1 |

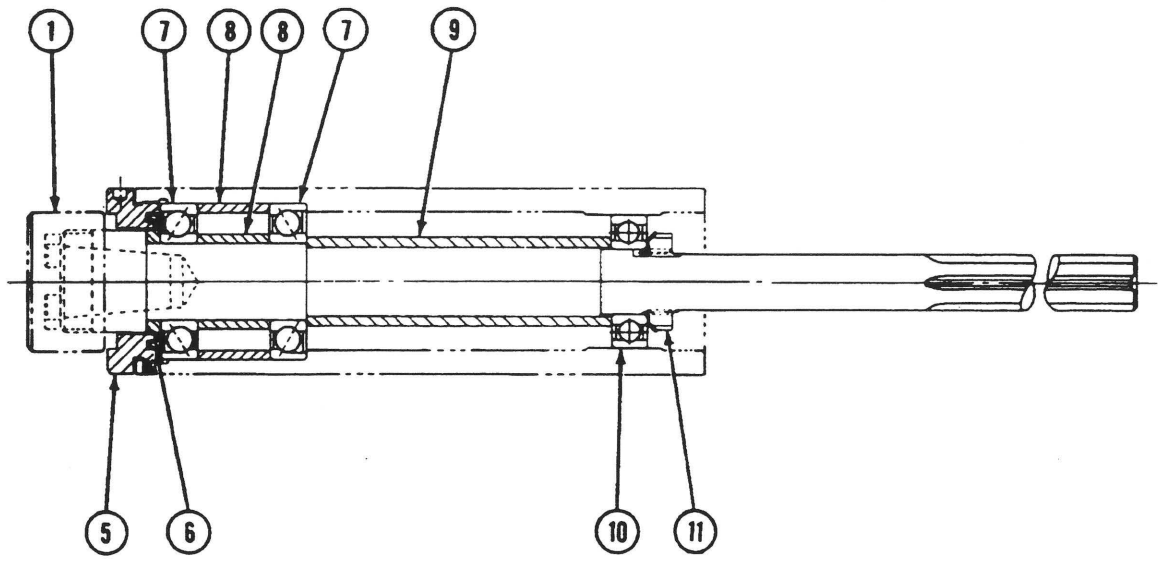
## #30 Q.C. SPINDLE ASSEMBLY—Dwg. 1-277-2900

| Item | Code No. | Description |
|---|---|---|
| 1 | 1157-0801 | #30 Q.C. Locknut Assembly<br>B.H.C.S., 10-32 x 0.250<br>B.H.C.S., 10-32 x 0.140<br>Cadmium-Plated B.H.C.S., 10-32 x 0.140 |
| 2 | 1157-2338 | Drive Key (2) |
| 3 | 1101-1007 | S.H.C.S., 8-32 x 0.500 (2) |
| 4 | 1157-0803 | #30 Quick Change Wrench |
| 5 | 1219-0514 | Kwick Change Wrench |
| 6 | 1278-0915 | Dirt Shield |
| 7 | 1177-1020 | Bearing (2) |
| 8 | 1219-3513 | Bearing Spacer (Set) |
| 9 | 1219-0197 | Bearing Sleeve |
| 10 | 1101-0241 | Grease Packed Bearing |
| 11 | 1119-1790 | Locknut |
| 12 | 1119-1942 | Lock Bearing Washer |
| 13 | 1277-0109 | #30 Erickson Spindle |



## #200 UNIVERSAL SPINDLE ASSEMBLY — Dwg. 2-277-2901

| Item | Code No. | Description |
|---|---|---|
| 1 | 1-177-0201 | #200 Universal Spindle Assembly |
| 5 | 1-219-0514 | Kwick Change Spindle Nut |
| 6 | 1-278-0915 | Dirt Shield |
| 7 | 1-177-1020 | Bearing (2) |
| 8 | 1-219-3513 | Bearing Spacer (Set) |
| 9 | 1-219-0197 | Bearing Sleeve |
| 10 | 1-101-0241 | Grease Packed Bearing |
| 11 | 1-119-1790 | Locknut |
| 12 | 1-119-1942 | Lock Bearing Washer |



## WAY LUBRICATION SYSTEM
### Dwg. 1-274-0303

| Item | Code No. | Description |
|---|---|---|
| 1 | 1-156-0085 | Tank Assy., Mist |
| 2 | 1-101-1035 | S.H.C.S., 0.250-20 x 1.000 |
| 3 | 1-141-3209 | Tank & Pump Assy. Way Lube |
| 4 | 1-101-1475 | R.H.M.S., 0.250-20 x 0.500 |
| 5 | 1-141-3292 | Gage Pressure |
| 6 | 1-165-1199 | B.H.C.S., 10-32 x 0.500 |
| 7 | 1-141-3213 | Junction, 4-Way |
| 8 | 1-101-1195 | B.H.C.S., 0.250-20 x 1.000 |
| 9 | 3-193-9977 | Cable Unit, Spray Mist |

## WAY JUNCTION LUBE ASSEMBLY
### Dwg. 1-141-0052

| Item | Code No. | Description |
|---|---|---|
| 1 | 1-141-0063 | Junction |
| 4 | 1-141-3219 | Comp. Nut (8) |
| 5 | 1-141-3221 | Comp. Sleeve (8) |
| 6 | 1-141-3225 | Nylon Tube (9 ft.) |
| 7 | 1-141-3211 | Metering Unit (5) |
| 8 | 1-141-3210 | Meter Unit (3) |
| 9 | 1-141-3225 | Plug Closure |
| 10 | 1-141-3220 | Comp. Bushing |
| 11 | 1-141-3224 | Brass Tube (0.417 ft.) |
| 12 | 1-141-3293 | Comp. Sleeve |

## BALLSCREW HOUSING LUBE
### Dwg. 1-274-9063

| Item | Code No. | Description |
|---|---|---|
| 38 | 1-101-1033 | S.H.C.S., 0.250-20 x 0.750 (5) |
| 802 | 1-101-1195 | B.H.C.S., 0.250-20 x 1.000 |
| 804 | 1-141-3219 | Comp. Nut |
| 805 | 1-141-3221 | Comp. Sleeve (3) |
| 806 | 1-141-3225 | Nylon Tubing (9 ft.) |
| 808 | 1-141-3210 | Meter Unit |
| 810 | 1-141-3220 | Comp. Bushing (3) |
| 811 | 1-141-3224 | Brass Tubing (0.333 ft.) |
| 812 | 1-141-3293 | Comp. Sleeve |
| 815 | 1-141-3212 | 3-Way Junction |
| 834 | 1-177-0089 | Meter |
| 835 | 1-177-0088 | 2-Way Junction |

## BASE ASSEMBLY LUBE

| Item | Code No. | Description |
|---|---|---|
| 802 | 1-101-1192 | B.H.C.S., 0.250-20 x 1.00 |
| 804 | 1-141-3219 | Nut Compression Sleeve (3) |
| 805 | 1-141-3221 | Compression Sleeve (9) |
| 806 | 1-141-3225 | Nylon Tube, 0.156 (3.5 ft.) |
| 810 | 1-141-3220 | Compression Bushing (3) |
| 812 | 1-141-3293 | Compression Sleeve (3) |
| 815 | 1-141-3212 | 3-Way Junction (2) |
| 823 | 1-141-3291 | Metering Unit (2) |
| 826 | 1-141-3233 | Terminal Nut, 0.375-24 |
| 827 | 1-141-3216 | Flexible Hose, 18 inch |
| 828 | 1-177-0081 | Female Coupling |
| 829 | 1-141-3290 | Tube Clip, 0.156 (2) |
| 830 | 1-141-0082 | Ballscrew Lubrication Tubing |
| 831 | 1-101-1466 | R.H.M.S., 10-3 x 0.500 (2) |

## QUILL HOUSING ASSEMBLY LUBE
### Dwg. 1-274-9062

| Item | Code No. | Description |
|---|---|---|
| 816 | 1-141-3222 | Elbow 90° Adapter |
| 821 | 1-165-1199 | B.H.C.S., 10-32 x 0.500 |
| 829 | 1-141-3290 | Tube Clip |

## HEAD ASSEMBLY LUBE
### Dwg. 1-274-9116

| Item | Code No. | Description |
|---|---|---|
| 804 | 1-141-3219 | Comp. Nut |
| 810 | 1-141-3220 | Comp. Bushing |
| 811 | 1-141-3224 | Brass Tubing (1.7 ft.) |
| 812 | 1-141-3293 | Comp. Sleeve (2) |

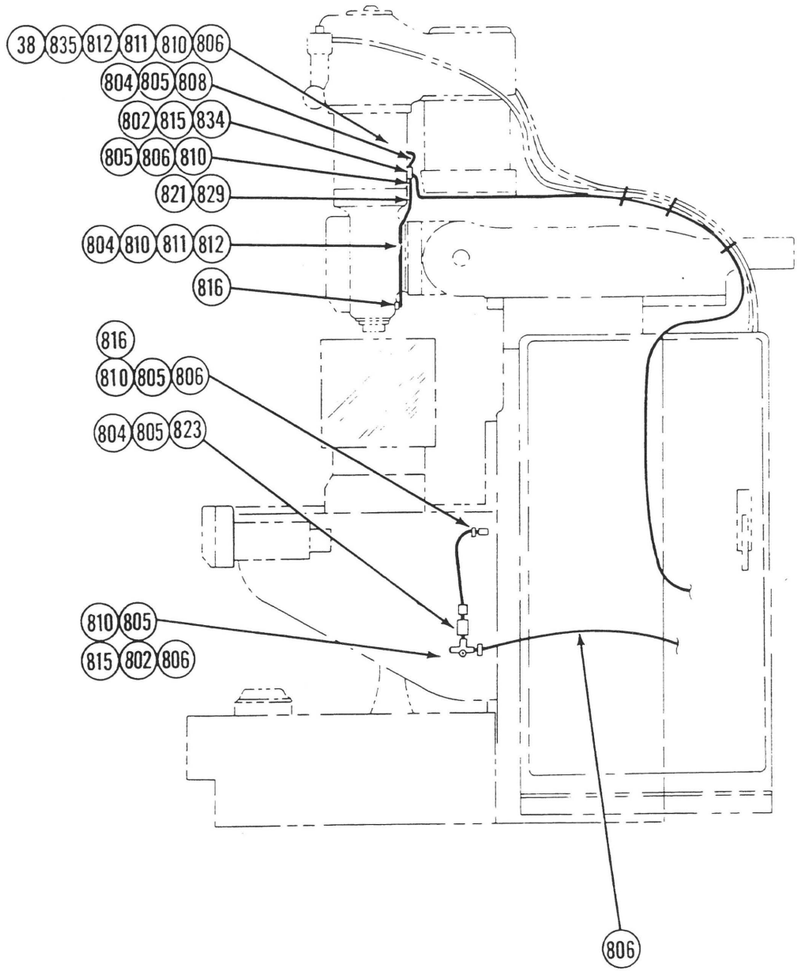
## SADDLE LUBE

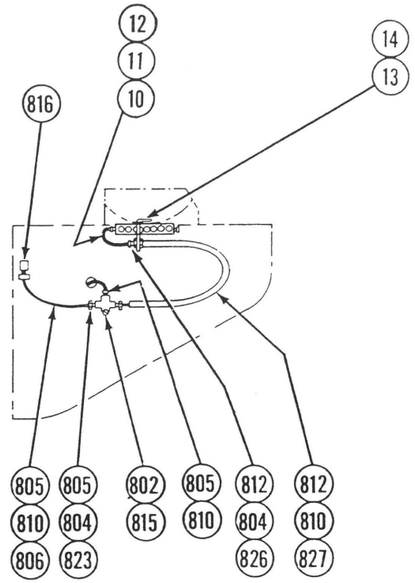
| Item | Code No. | Description |
|---|---|---|
| 3 | 1-141-3235 | Drive Bushing (6) |
| 2 | 1-101-1477 | R.H.M.S., 0.250-20 x 1.000 (2) |
| 13 | 1-141-3230 | Bracket |
| 14 | 1-101-1475 | R.H.M.S., 0.250-20 x 0.500 |
| 25 | 1-141-3236 | Tubing Clip (2) |
| 31 | 1-101-1429 | R.H.M.S., 8-32 x 0.500 (2) |

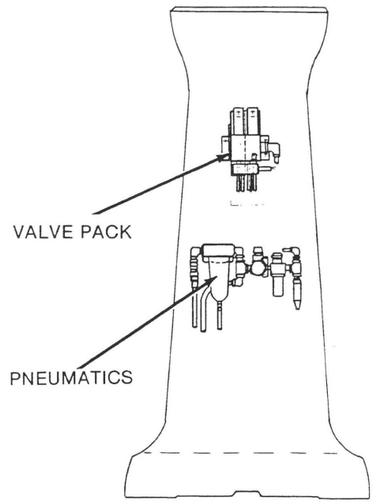
# 12. Parts Breakdown

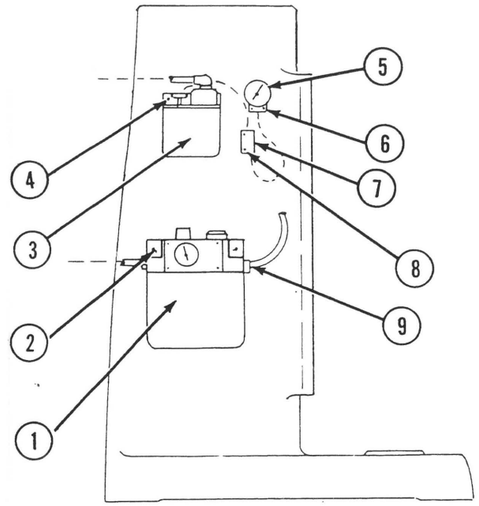
**Lubrication Point Chart**

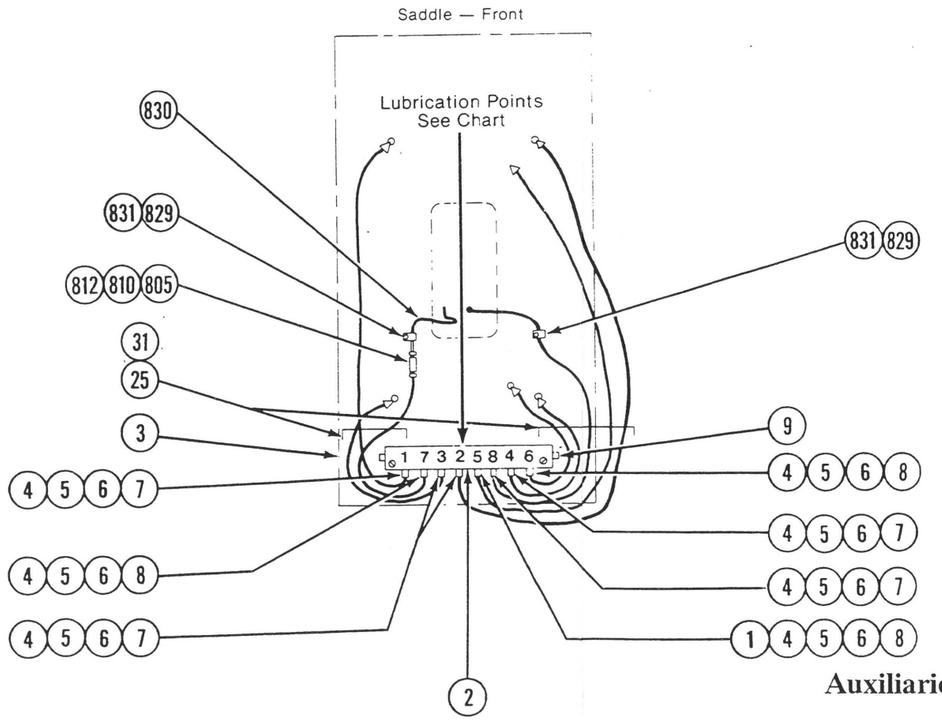
| No. | Description |
|---|---|
| 1 | Table Way and Gib Right Rear |
| 2 | Table Way and Gib Right Front |
| 3 | Table Way and Gib Left Rear |
| 4 | Table Way and Gib Left Front |
| 5 | Knee Way and Gib Right Front and Rear |
| 6 | Knee way and Gib Left Front and Rear |
| 7 | "Y" Axis Ballnut |
| 8 | "X" Axis Ballnut |



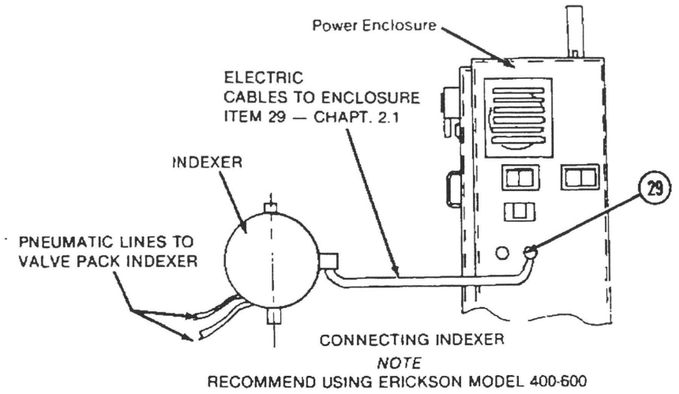



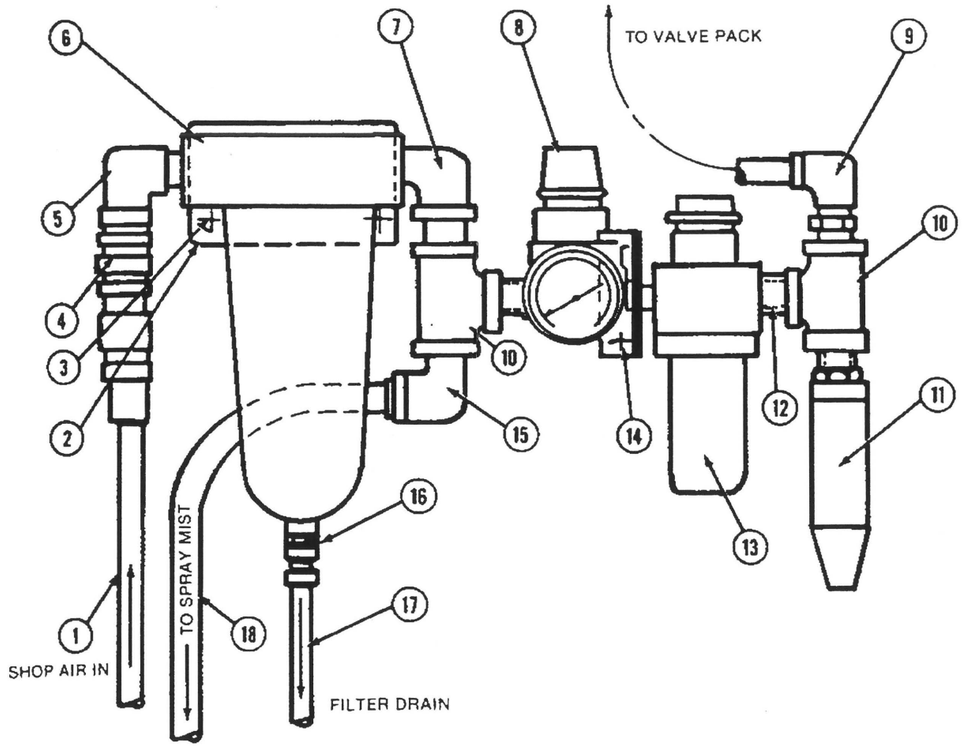



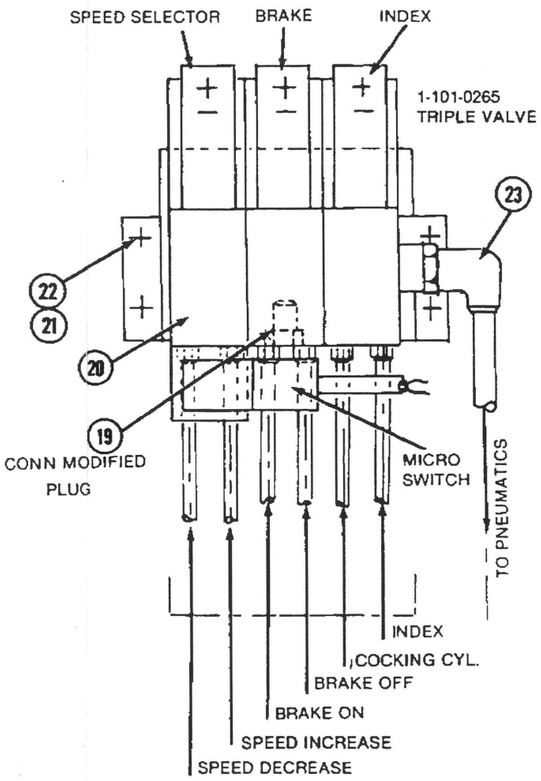

**Auxiliaries System**

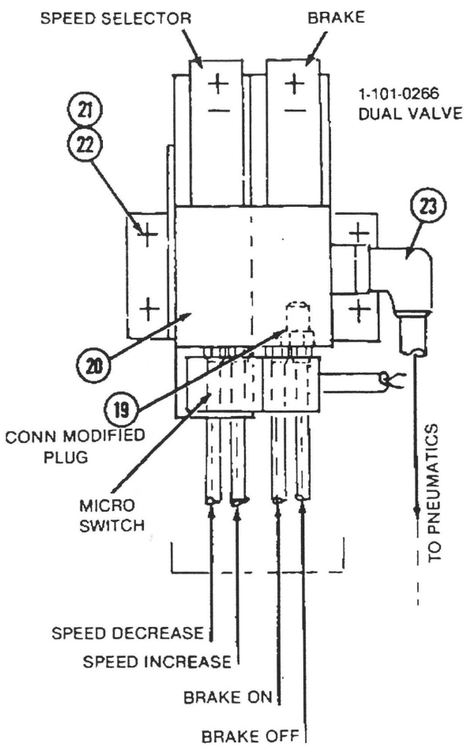
**6.3 LUBE, MIST AND PNEUMATICS —**
**Dwg. 1-274-0303**

| Item | Code No. | Description |
|---|---|---|
| 1 | 3-192-7875 | Hose Assy. |
| 2 | 3-150-6461 | Bkt, Mounting |
| 3 | 3-150-8040 | Screw, TF .250-20x.620 (2) |
| 4 | 3-150-7920 | Valve, 3-Way - Sleeve Oper |
| 5 | 3-150-2418 | Elbow, 90° Street |
| 6 | 1-101-0311 | Filter, Air |
| 7 | 3-150-5912 | Elbow, .250 90° Street |
| 8 | 1-101-0264 | Regulator, Miniature |
| 9 | 3-154-1438 | Elbow, 90°, Male, Swivel |
| 10 | 3-150-2724 | TEE,.250 CAD Plate, Female (2) |
| 11 | 1-101-0315 | Switch, Press, Oper |
| 12 | 3-150-5305 | Nipple, .250 Close, Parker (4) |
| 13 | 1-101-0263 | Lubrication, Air Oper |
| 14 | 1-174-0301 | Bkt, Support |
| 15 | 3-154-1438 | Elbow, 90° Male S.W.I. (U/W Spray Mist) |
| | 1-101-0779 | Plug, Pipe (W/O Spray Mist) |
| 16 | 1-101-0239 | Connector, Parker #68P |
| 17 | 3-150-1912 | Tubing, Thermoplastic (5 ft.) |
| 18 | 3-154-1440 | Tubing, Polyethylene, .375 OD |
| 19 | 3-193-9142 | Plug, Conn. Mod. (Brake Off) |
| 20 | 1-101-0266 | Valve, Dual Pack (W/O Index) |
| | 1-101-0265 | Valve, Triple Pack (W/Index) |
| 21 | 1-165-1943 | Washer Lock .250 S (4) |
| 22 | 1-101-1035 | S.H.C.S. .250-20x1.00 (4) |
| 23 | 3-154-1439 | Elbow, 90° Male |




**Lube, Mist and Pneumatic**

# 12. Parts Breakdown

## WAY LUBRICATION TANK & PUMP ASSEMBLY — Dwg. 1-141-3209

| Item | Code No. | Description |
|---|---|---|
| A | 1-141-7850 | Waylube Motor |
| B | 1-141-3241 | Float Switch |
| C | 1-141-0078 | Inlet Filter Group |
| D | 1-141-0079 | Reservoir |
| E | 1-152-3132 | Waylube 1180, Quart Can |

**NOTES**

Lubrication Frequency

5cc every 27.7 mins. (60 Hz)

5cc every 32.0 mins. (50 Hz)

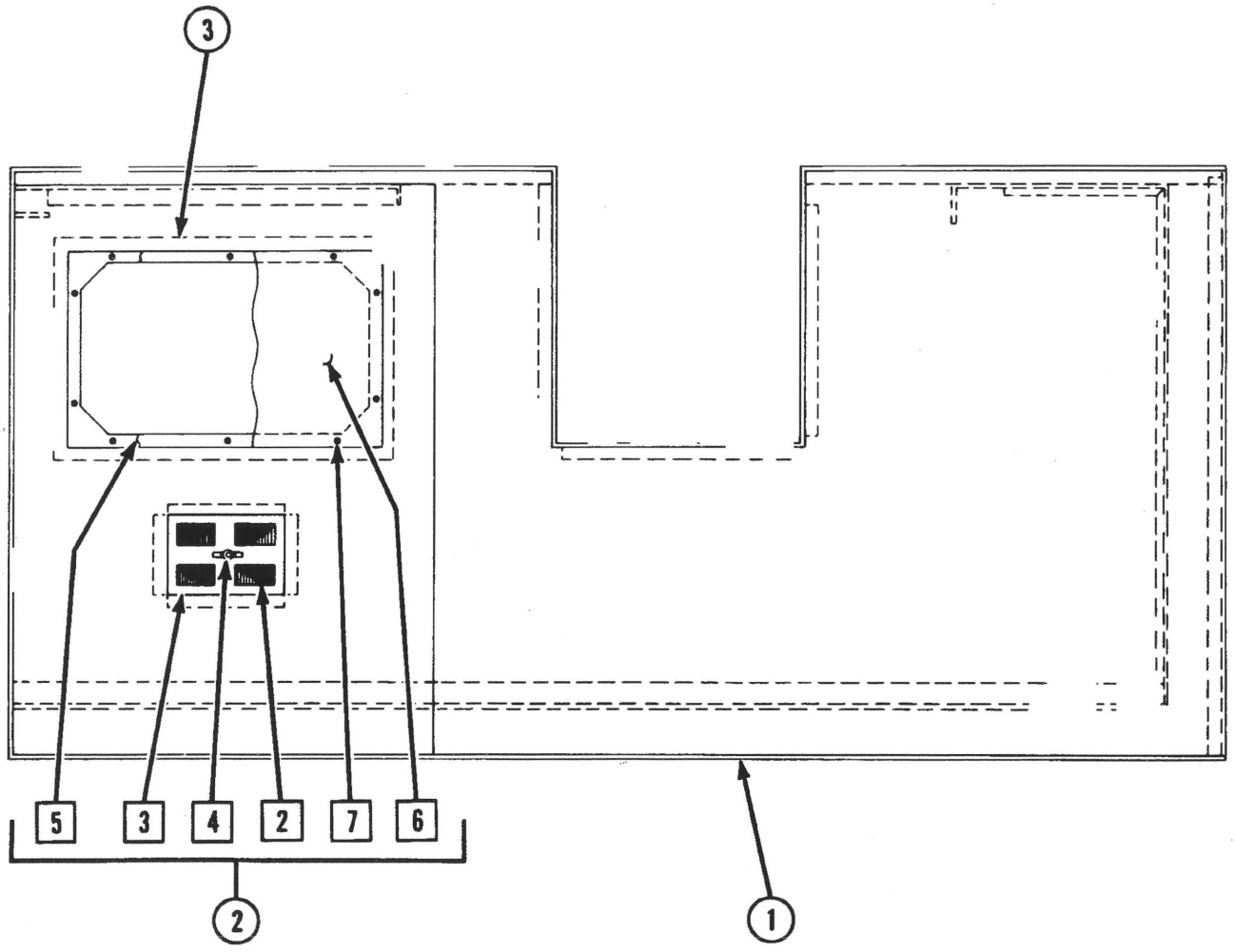
Refill every 100 hours of operation

## BASE PAN AND FILTER ASSEMBLY — Dwg. 3-193-7623

| Item | Code No. | Description |
|---|---|---|
| 1 | 3-193-6542 | Flood Base Pan Assy. |
| 2 | 3-193-7888 | Base Pan Kit |
| 3 | 3-193-6544 | Reservoir |

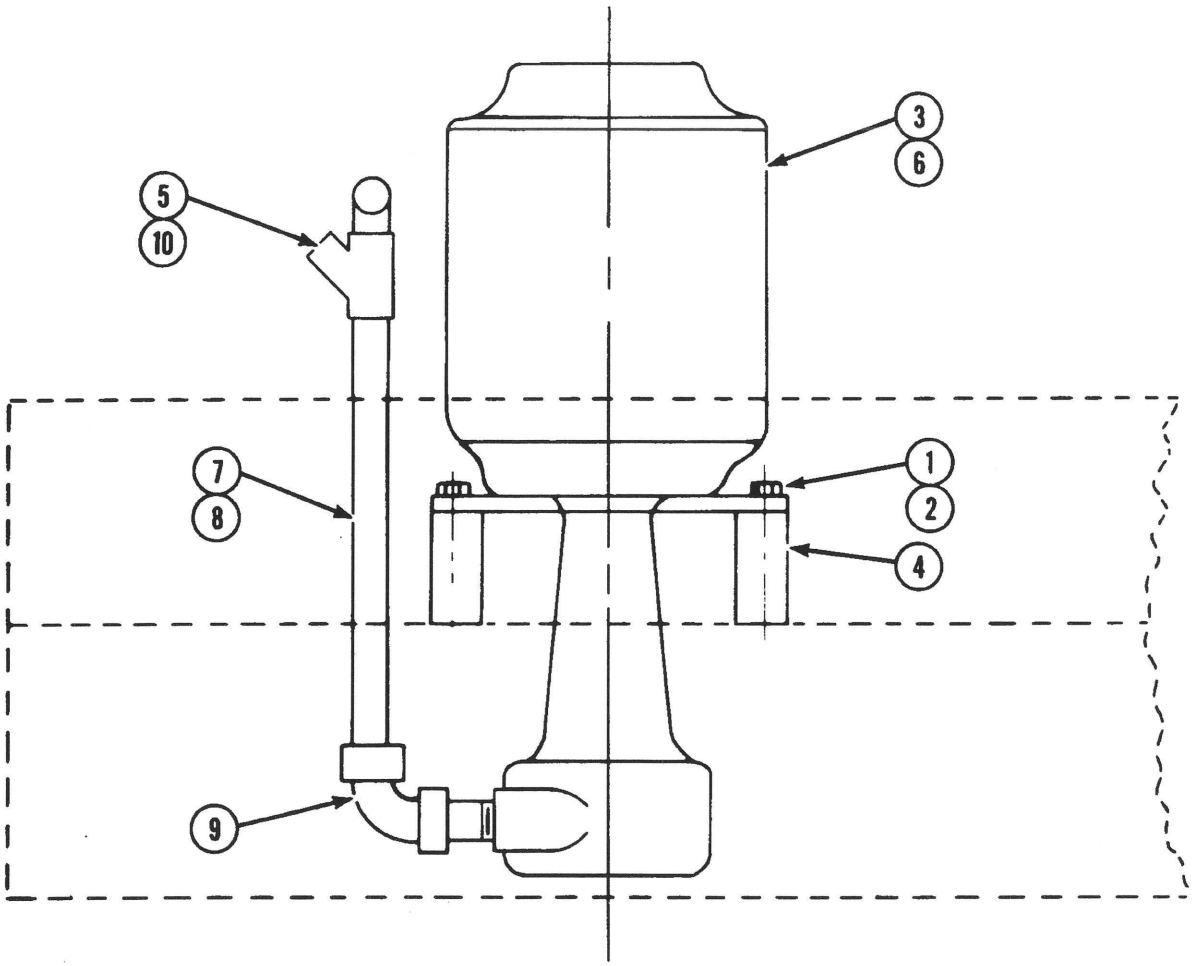
## BASE PAN KIT — Dwg. 3-193-7888

| Item | Code No. | Description |
|---|---|---|
| 2 | 3-193-7618 | Filter |
| 3 | 3-193-7619 | Plate Filter |
| 4 | 3-154-1135 | Wing Nut |
| 5 | 3-193-7620 | Pump Plate Gasket |
| 6 | 3-193-7622 | Pump Plate |
| 7 | 3-154-1113 | Thd. Forming Screw |



## FLOOD COOLANT PUMP AND MOTOR
## Dwgs. 1-256-0169 (60 HZ) & 1-256-0171 (50 HZ)

| Item | Code No. | Description |
|---|---|---|
| 1 | 101-1138 | H.H.C.S., 0.250-20 x 0.750 |
| 2 | 1-111-1912 | Flat Washer, 0.250 |
| 3 | 1-156-0163 | Coolant Pump and Motor (60 HZ) |
| | 1-156-0261 | Coolant Pump and Motor (50 HZ) |
| 4 | 1-156-0158 | Pump Spacer |
| 5 | 1-156-2671 | Check Valve |
| 6 | 3-192-5862 | Flood Coolant Cable |
| 7 | 1-198-0904 | Pipe Nipple, 0.500 |
| 8 | 1-198-0941 | Pipe Nipple, 0.500 |
| 9 | 1-198-0971 | Elbow — 90° Iron |
| 10 | 1-198-1425 | Elbow — 90° CD |



## FLOOD COOLANT, 1 NOZZLE/HEAD, 1 HEAD (TANK ON FRONT) —

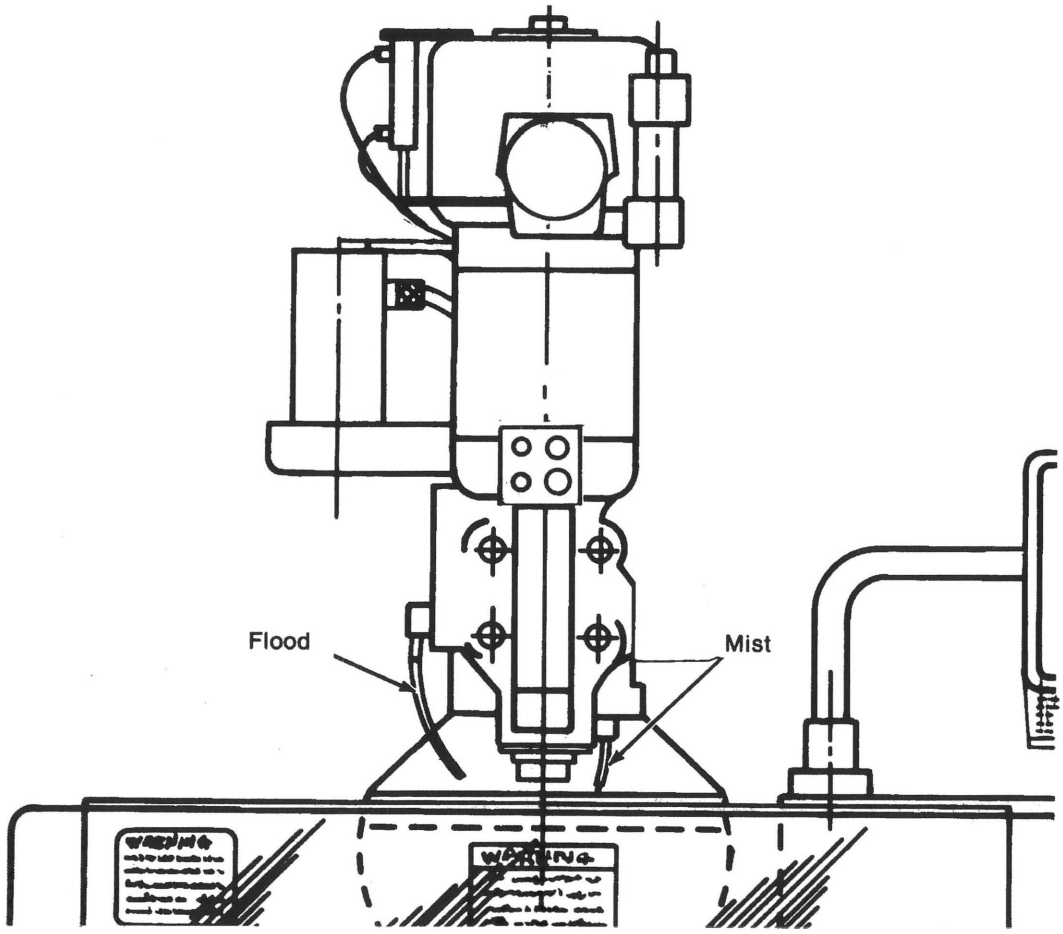
**Dwg. 1-256-0128**

| Code No. | Description |
|---|---|
| 1-166-5661 | Shut Off Valve |
| 1-112-2665 | Cable Tie |
| 1-101-1010 | S.H.C.S., 10-24 x 0.500 |
| 1-156-0263 | Coolant Hose, 15 in. Lg. |
| 1-156-5470 | Vinyl Tubing, 0.750 x 1.000 |
| 1-156-5482 | Elbow, 0.5 x 0.75 |
| 1-163-5040 | Plug Pipe |
| 1-165-2528 | Cable Hp 14N Burndy Clamp |
| 1-171-0120 | Dupage Hose Clamp, 6 |
| 1-171-5470 | Vinyl Tubing, 0.500 x 0.625 |
| 1-256-1010 | Manifold Block |
| 1-156-5484 | Hose Fitting |

## NOZZLE ASSEMBLIES — (FLOOD AND MIST)

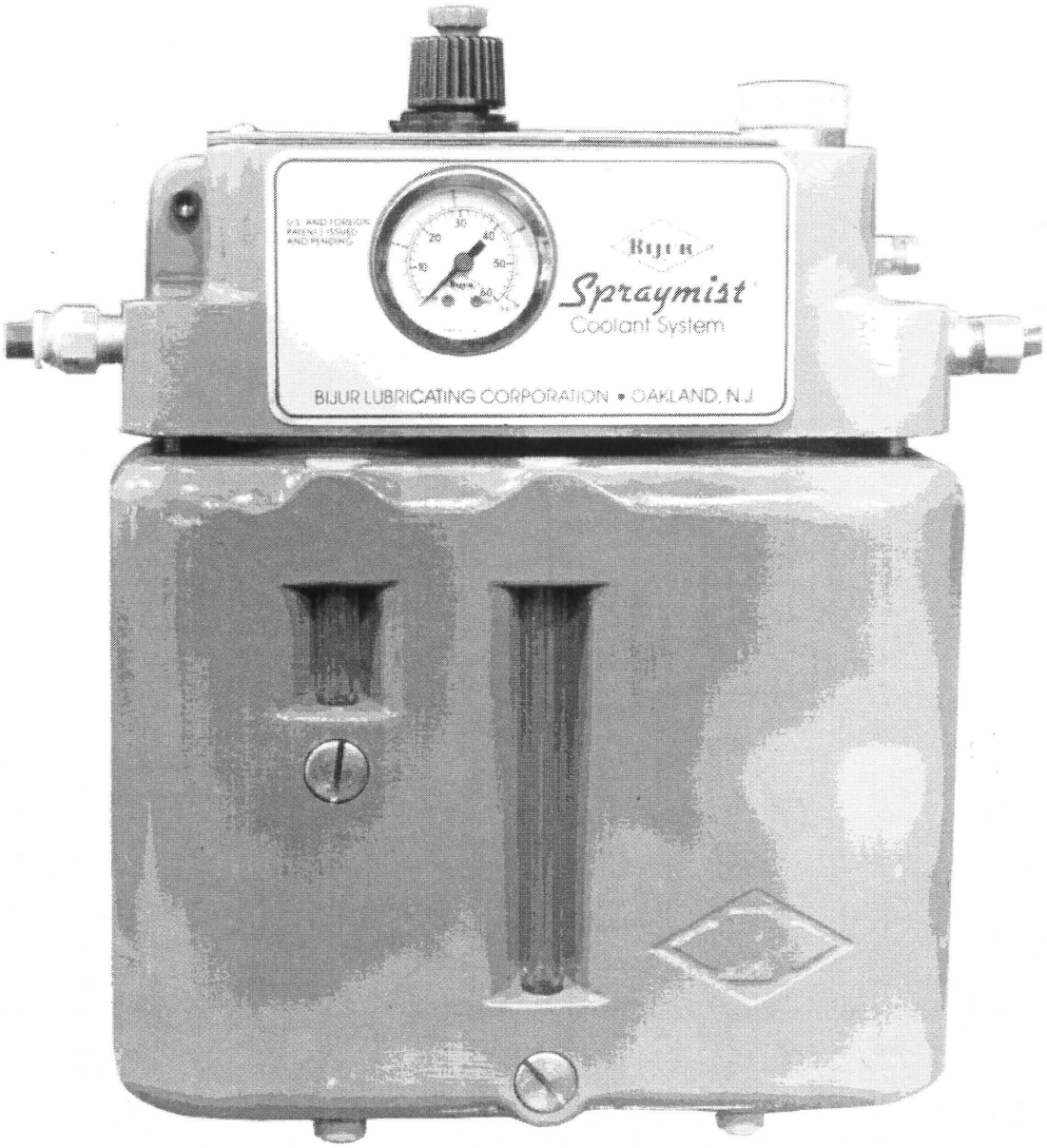
**Mist Coolant, 1 Nozzle (Tank on Side) — Dwg. 1-256-0076**

| Code No. | Description |
|---|---|
| 1-156-0086 | Flexible Jet |
| 1-156-0087 | Hose Assembly |
| 1-156-0088 | Tube Adapter |
| 1-156-0089 | Hose Connector |
| 1-156-0090 | Hose Connector, 5/16 |
| 1-156-0091 | Jet Holder |



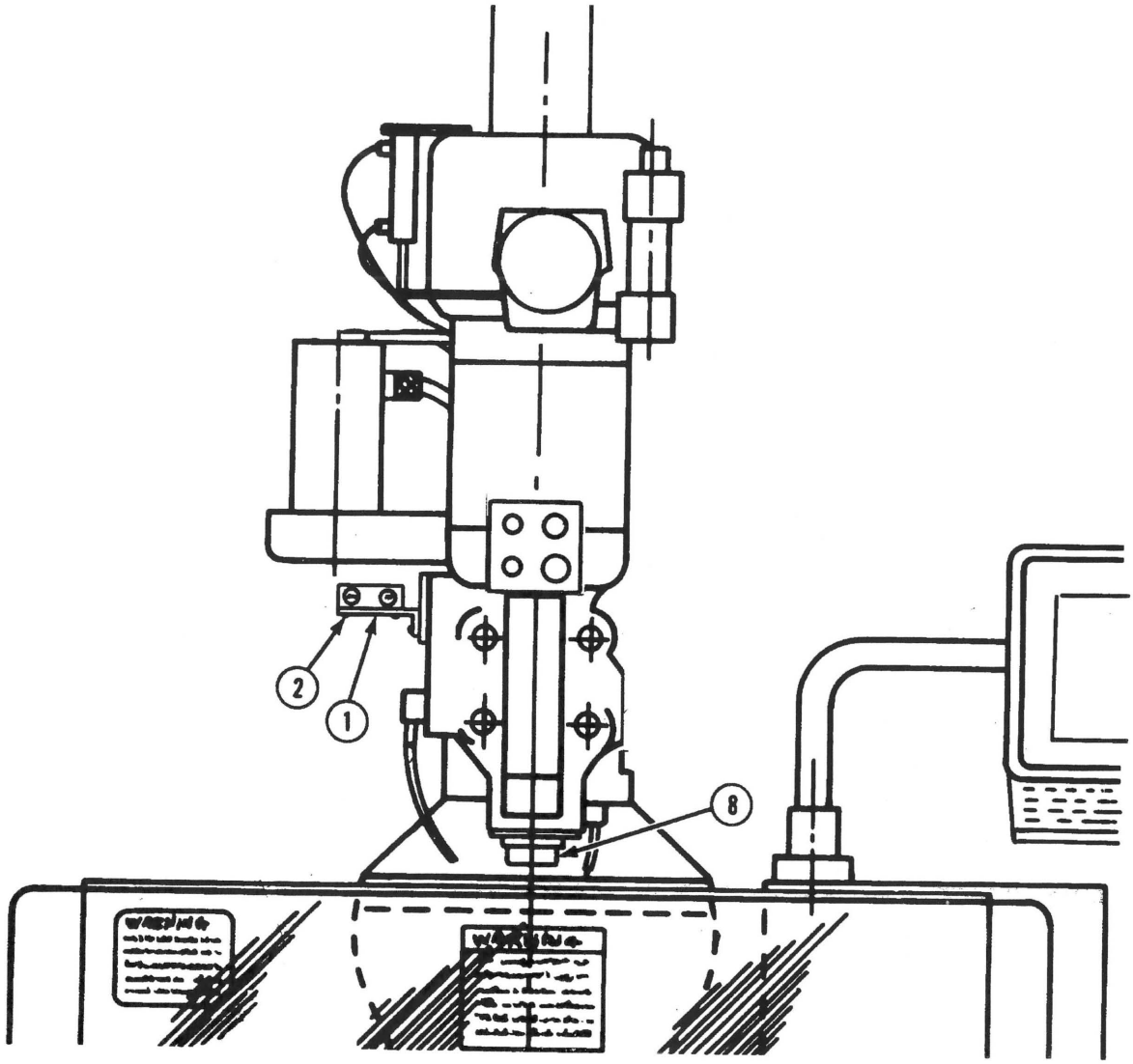
## MIST TANK ASSEMBLY — Dwg. 1-156-0085

| Code No. | Description |
|---|---|
| 1-101-1477 | R.H.M.S., 0.250-20 x 1.000 |
| 1-101-1535 | F.H.M.S., 0.312-18 x 1.000 |
| 1-111-1912 | Flat Washer, 0.250 |
| 1-156-0085 | 1 Gallon Spray Mist Tank |



## POWER DRAWBAR KIT — Dwg. 1-374-9060

| Item | Code No. | Description |
|---|---|---|
| 1 | 3-193-9543 | Switch Mounting Bracket |
| 2 | 1-165-1199 | B.H.C.S., 10-32 x 0.500 (2) |
| 4 | 1-101-0240 | Tee |
| 5 | 1-101-0238 | Power Drawbar Kit |
| 7 | 1-157-0570 | Power Drawbar Kit |
| 8 | 1-257-0588 | Installation Spindle Sleeve |
| 13 | 1-101-0251 | Elbow |



Reference paragraphs noted below are those contained earlier in this manual.

**POWER EQUIPMENT ASSEMBLY — Dwg. 3-194-1133**

| Item | Code No. | Description |
|---|---|---|
| NA | 3-154-2047 | Overload Relay 230 |
| NA | 3-154-2050 | Overload Relay 460 |
| 8 | 3-154-2046 | Starter Reversing |

Fuse — See Table 13.1

**DRIVE POWER SUPPLY ASSEMBLY — Dwg. 3-193-9893**

| Item | Code No. | Description |
|---|---|---|
| 18 | 3-150-8110 | BR-1BR-2 Bridge Rectifier |

Fuses — See Table 13.1

**OPERATOR'S CONTROL PANEL ASSEMBLY — Dwg. 3-194-1029**

| Item | Code No. | Description |
|---|---|---|
| 2 | 3-154-0811 | Spindle Hi-Lo |
| 3 | 3-154-8790 | Emergency Stop |
| 4 | 3-150-4166 | Hold |

**OPERATOR STATION ASSEMBLY — DWG. 3-194-0975**

| Item | Code No. | Description |
|---|---|---|
| 4 | 3-154-0630 | Spindle Off |
| 5 | 3-150-8790 | Emergency Stop |
| 6 | 3-150-4479 | Jog |
| 7 | 3-154-0234 | Axis Motion Encoder |

**BASE ASSEMBLY — Dwg. 1-274-9031**

| Item | Code No. | Description |
|---|---|---|
| 47 | 1-106-0205 | Bearing |
| 127 | 1-106-0203 | Bearing (2) |
| 82 | 1-106-0204 | Bearing |
| | 3-194-1086 | DC Servo Motor Assembly |
| 120 | 1-165-2116 | Timing Special Belt |
| 135 | 1-165-2113 | Timing Belt |

**HEAD ASSEMBLY — Dwg. 1-274-9116**

| Item | Code No. | Description |
|---|---|---|
| 70 | 1-180-0012 | Z Drive Belt |
| 31 | 1-117-0262 | Bearing |
| 36 | 1-118-2120 | Spindle Drive Belt |
| 52 | 1-155-2106 | Back Gear Belt |
| 84 | 1-118-0254 | Bearing (2) |
| 129 | 1-118-0235 | Bearing (2) |
| 130 | 1-177-0118 | Z-Axis Ballscrew Bearing |
| 22 | 1-118-0252 | Bearing |
| 18 | 1-194-1086 | DC Servo Motor Assembly |

**PNEUMATIC SPEED CHANGER — Dwg. 1-274-9068**

| Item | Code No. | Description |
|---|---|---|
| 38 | 1-177-0273 | Air Motor Cast |
| 39 | 1-177-0279 | Lovejoy Coupling |
| | 3-154-1652 | Spindle Speed Potentiometer |

**WAY LUBRICATION TANK AND PUMP ASSEMBLY— Dwg. 1-141-3208**

| Item | Code No. | Description |
|---|---|---|
| A | 1-141-7850 | Waylube Motor |

**INDEX CONTROL KIT —**

| Item | Code No. | Description |
|---|---|---|
| 21 | 1-101-0266 | Dual Valve Pack Without Index |
| | 1-101-0265 | Triple Valve Pack With Index |

**BASE PAN KIT — Dwg. 3-193-7888**

| Item | Code No. | Description |
|---|---|---|
| 2 | 3-193-7618 | Filter |
| 3 | 3-193-7619 | Plate Filter |
| 4 | 3-154-1135 | Wing Nut |
| 5 | 3-193-7620 | Pump Plate Gasket |
| 6 | 3-193-7622 | Pump Plate |
| 7 | 3-154-1113 | Thd. Forming Screw |

# Appendix A. System Specifications

## A.1 OVERVIEW

The V2XT machine design is dedicated to Computer Numerical Control. The following four sections list the systems mechanical and electrical specifications and features.

## A.2 FEATURES OF THE SERIES I V2XT

1. Bridgeport Standard Series I machine frame.
2. Vertical, heavy-duty spindle with extra precision bearings in 3-3/8 in. dia. quill.
3. #30 quick change tooling with optional Power Drawbar.
4. 3 hp duty rated, fan-cooled ac induction motor with air-operated spindle brake.
5. Airflow through the belt housing minimizes spindle growth, reduces belt wear and promotes long bearing life.
6. Spindle speeds 60-4200 rpm with air turbine power-operated speed changer.
7. Head design based upon the proven (2J) model
8. High inertia spindle assembly characteristic of good milling capabilities.
9. Standard V-Ram featuring in-out motion by rack and pinion manual adjustment.
10. Patented V-Ram clamp mechanism to provide the needed rigidity.
11. Tilting mechanism for the V-Ram head featuring versatility to machine at many angles.
12. Large diameter turret support with swivel capability on spindle clamp to standard column.
13. Dovetail ways throughout with large contact area to promote good milling characteristics.
14. Chrome-plated ways at table-to-saddle and saddle-to-knee juncture.
15. Single gib provides adjustment in two planes on each way system to compensate for wear.
16. Dual special locks on the side of the knee to bind the knee to the rigid column.
17. T-slot spacing standard (5/8 in. on 2.5 in. centers) on standard 9 x 48 in. table.
18. Allows machining at almost any angle on a part.
19. Automatic one-shot way lubrication system with low level protection.
20. Ballscrews 1-l/4 in. diameter in X and Y-axes.
21. Z ballscrews 2 in. diameter—a ball quill design.
22. Center guideway system for maximum accuracy and best repeatability of position.
24. Ballscrews supported by steep angular contact, high precision combination radial/thrust bearings in heavy bracket.
25. Axis drive motors mounted entirely clear of the operator's working area.
26. Travel limit switches with lamp indicator and over-ride.
27. Closed loop dc servo drives with encoder feedback.
28. Sealed power cabinet mounted on the machine structure.
29. Automatic and manual control of flood/mist coolant (optional) systems.
30. Chip and coolant shield and splashback supplied as standard equipment.
31. Chip and coolant collector pan below the working area (optional).
32. Single electrical power connection to fusible disconnect.
33. Electrical construction complies with the intent of NFPA 70 and 79.
34. Control cabinet is mounted on the machine structure.
35. Diagnostic routine automatically conducted every time power is turned on.
36. Interlock on feed if spindle is not operating.
37. Factory scheduled school for general training in operating/programming (one student — one week).
38. Factory scheduled school for maintenance (one week and special fee).

39. Factory trained service engineer's startup and operator training (one day).
41. One-year warranty on materials and workmanship of Bridgeport's manufacture.

## A.3 BRIDGEPORT DX-32 CONTROL SPECIFICATIONS

### Introduction

The Bridgeport DX32 PCNC control is a PC based advanced controller that provides three levels of services: 1) A user-machine interface (UMI) that features a general purpose DOS based software environment, 2) A machine controller (MC) that contains a real time operating system that supports interpolation and motion control functions, and 3) A programmable logic controller (PLC) that handles the low level machine input-output signals.

The design philosophy of the DX32 is consistent with the requirements for an Open Architecture Control - the use of well defined and documented interfaces permit the DX32 to be expanded and enhanced by either 1) Bridgeport , 2) a systems integrator, or 3) the end user or third party vendors developing advanced manufacturing technology. Open Architecture provides a considerable improvement over the previous generation closed CNC controllers built using hardwired logic. The openness of the DX32 facilitates the addition of new controller features and innovative technology with a relative ease that is unavailable in controllers that have a closed design. The inherent benefits of an open control are two-fold: (1) the end-user has a controller that is adaptable to market dynamics and can be up-graded to incorporate the latest technology, and (2) third-party vendors have the opportunity to develop value added accessory hardware/software to cater to and service particular user needs. The measurable benefits of an Open Architecture control are:

| CAPABILITY | DESCRIPTION |
|---|---|
| **ENHANCEMENT** | Ability to add features designed to user needs (e.g. touch probe, vibration sensors, window for TV monitor, voice annunciation of alarms) |
| **INTEROPERABILITY** | Ability to easily interchange control components (e.g. PLC axes and spindle servo drives) |
| **SCALABILITY** | User modification of the control to change how a feature is performed (e.g. Customized screens, Foreign Language, Bezier interpolation, Knowledge based machining strategies ) |
| **PORTABILITY** | Ability to use off-the shelf DOS based software components (e.g Statistical Process Control (SPC) software, CAM software, etc. |
| **PHYSICAL CONNECTION** | Open facility for physical hardware interfaces (e.g. serially chained auxiliary function boards.) |
| **NETWORKING** | Ease of connection with peers and factory systems (e.g. Windows for Workgroups) |
| **PERFORMANCE** | The result of the ability to easily upgrade the control to a level of robustness consistent with user needs. |

# Appendix A. System Specifications

## HARDWARE

### Structure:

The control spans three separate timing domains: the Standard Computer (SC) Domain, the Real-Time (RT) Domain and the Hard Real-Time (RT) Domain. The User-Machine Interface runs within the SC Domain using DOS as the operating system. A background task continuously polls the status of the machine controller and displays system status. Otherwise there are no time requirements in the SC domain to complete an activity. File handling, remote communications, manufacturing information and DOS level support software run in the SC Domain.

The machine controller supervises the RT Domain and has primary responsibility for all Hard RT activities. Events in the RT domain run in the outer (polled) timing loop of the Machine Controller and consist of tasks that are not very time critical - for example: parsing the part-program , updating status messages and checking for operator interaction. Hard RT activities run in the inner (interrupt driven) loops of the Machine Controller and have mandated timing deadlines - for example: path interpolation and axis servo control.

### UMI. User-Machine Interface:

The Bridgeport DX32 PCNC control uses a 32 bit 80386DX 33Mhz motherboard with 4M of Random Access Memory (RAM). A standard PC ISA bus is used for board inter-connectivity. A VGA graphics board and a Peripheral Controller board that provides 2 serial interfaces, a parallel interface, a floppy disk drive controller and a IDE hard drive controller are also plugged into the PC motherboard. A 3-1/2 Diskette Drive with 1.4M byte capacity is provided as a convenient means of entering data into the control and archiving data from the control. A 80M byte Hard Disk Drive is used to store both system software and user data.

### Machine Controller:

A Bridgeport designed machine controller (BMDC) plugs directly into the PC ISA bus - communication between the PC and the BMDC is via shared RAM. This unique design provides a considerable performance improvement over other PC based CNCs that have the PC loosely connected to the machine controller via a serial link. The BMDC features a 32 bit 68030 36Mhz processor with an on-board 96 bit math coprocessor. The use of the math processor and internal representation of data as double precision floating point values enable the BMDC to provide 14 digit precision. The high speed computational ability of the BMDC provides data through put of 400 blocks per second.

### Machine I/O:

A high speed (38.4 K baud) serial I/O channel provides means for chaining intelligent peripheral controllers to the machine controller.

## OPERATOR INTERFACE

A VGA monitor, pop-up windows and soft keys makes control operation fast and easy. The various control functions are designated on the display screen as key coded pushbuttons. Operating the designated numeric or function key activates the function. The top-level selectable functions are : MDI, TEACH, RUN, JOG, SET, MOVE, and UTILS. The MDI ( Input a part program) mode incorporate a formdriven conversational mode that prompts the operator to fill in the fields required to input data for a particular operation. UTILS provide access to DOS level software. On-line context sensitive HELP screens provide the information required to do an operation or program a command.

# Appendix A. System Specifications

**SYSTEM FEATURES**

CONTROLLED AXES: 5 axis control with automatic acceleration and deceleration. (X,Y,Z,C,S)
4 axis simultaneous linear interpolation (XYZC)
2 axis multi-quadrant circular interpolation (XY,YZ,XZ)
3 axis helical interpolation (XYZ)
3 axis spirical interpolation (XYZ)
2 axis rigid tapping (S,Z)

INPUT RANGE 14 numeric digits (not including decimal point or minus sign).

CONTROL RESOLUTION: 1 centi-micrometer (0.00001mm)

SERVO ITERATION RATE 2000 its/sec

FEEDRATE OVERRIDE 10 to 150%

SPINDLE SPEED OVERRIDE 10 to 150%

DRY RUN: NO Z/ MAX F

OPTIONAL BLOCK STOP

PART PROGRAM STORAGE: 256,000 characters (batch mode). 80,000,000 characters (on-line DNC)

PRE-READ BUFFER 3 blocks

DECIMAL POINT INPUT

DNC MODE. Programs over 256K can run directly from data stored in the hard disk

DATUM POINT SETTING (floating zero point)

TOOL DEFINITIONS: 24

TOOL TABLE DISPLAY: LENGTH /DIAMETER

ONE BUTTON TOOL LENGTH SETTING

CLEAR POINT

SERIAL INTERFACE: One RS 232C. PARALLEL INTERFACE: One

MDI keyboard

VGA CRT display

GRAPHIC S PREVIEW

FILES MANAGEMENT UTILITIES

TEACH MODE

Bridgeport conversational mode program data entry

FANUC G-CODE compatible input

EDIT commands: CUT/COPY/PASTE/RESEQUENCE/REVISE/DELETE/MODIFY

ON-LINE HELP

PART PROGRAM SEARCH: Sequence number, Tool Number

OPERATION MODES: AUTO, SINGLE STEP, DRY RUN

JOG CONTROLS: JOG +/- PUSHBUTTONS:INCREMENTAL/CONTINUOUS JOG. ELECTRONIC HANDWHEEL

COMPENSATION: backlash and leadscrew pitch error

PASSWORD BASED KEY-LOCK PROTECTION

MACHINE SPECIFICATION PARAMETER FILE

DIAGNOSTIC ROUTINES

SOFTWARE AXIS LIMITS

# Appendix A. System Specifications

**PROGRAMMING FEATURES**

MULTI FORMAT PART PROGRAM INPUT: SHOP LANGUAGE/ RS274D (G-CODE) with Bridgeport extensions

ABSOLUTE/INCREMENTAL INPUT. U,V,W,B can be used to specify incremental X,Y,Z,A values

MULTI-QUADRANT CIRCULAR INTERPOLATION (XY,YZ,XZ)

ARC PROGRAMMED by center point or by radius.

HELICAL (internal or external threads), SPIRICAL (pipe threads) INTERPOLATION.

POLAR COORDINATES

TRANSFORMATIONS: TRANSLATE,ROTATE,SCALE,MIRROR

PROGRAM CODE: EIA RS274D

PROGRAM NUMBER: and 8 digits

SEQUENCE NUMBER N and 5 digits

FEEDRATE - direct command.

IPM,IPMM, IPR with constant vector velocity control.

RAPID TRAVERSE RATE set by PARAMETER.

AUTOMATIC ACCELERATION-DECELERATION

DECELERATION OVERRIDE

FOLLOWING ERROR DETECTION

FEEDRATE SLOWDOWN AT DESIGNATED SPINDLE LOAD

SPINDLE SPEED - direct command.

RIGID TAPPING. Coordinated S,Z motion with inches/revolution feed rate.

TOOL SELECTION - direct command.

PROGRAMMABLE SPINDLE ORIENT

MISCELLANEOUS FUNCTION: PROGRAM STOP/ OPTIONAL STOP/ END OF PROGRAM/ SPINDLE ON CLW- ON CCLW- OFF/ TOOL CHANGE/ COOLANT FLOOD-MIST-OFF/ SPINDLE ORIENT/ PROGRAM STOP @ CLEAR POINT/ OPTIONAL STOP @ CLEAR POINT/ END OF PROGRAM @ CLEAR POINT/ QUILL HOME/ TOOL CHANGE @ CLEAR POINT/ ADVANCE INDEX TABLE.

INCH OR METRIC PROGRAMMING

TOOL LENGTH OFFSET - 24 values

TOOL DIAMETER COMPENSATION - 24 values with programmable automatic corner rounding.

ROUNDING OF CORNERS. LINE-LINE/ LINE-ARC/ ARC-ARC

CORNER CHAMFERING

DWELL

MACRO SUBROUTINE CALLS with stacked parameters

REPEAT LOOPS nested 4 deep

PARAMETRIC PART PROGRAMMING LANGUAGE (PPPL). ASSIGNMENT STATEMENTS/ ARITHMETIC OPERATORS/ RELATIONAL OPERATORS/ LABELS/CONDITIONAL PROGRAM CONTROL STATEMENTS/MATHEMATICAL FUNCTIONS.

CANNED CYCLES, MILLING: OUTSIDE FRAME/INSIDE FRAME/ POCKET FRAME/ OUTSIDE FACE/ INSIDE FACE/ OUTSIDE CIRCLE/ INSIDE CIRCLE/ POCKET CIRCLE/ SLOT/CIRCULAR SLOT.

CANNED CYCLES, DRILLING: DRILL/SPOTFACE/ DEEP HOLE DRILL/ TAP/ BORE/ BORE with STOP/ CHIPBREAK/ BORE with DWELL.

DRILLING CANNED CYCLES: ROW/BOLT CIRCLE/PARTIAL BOLT CIRCLE/ FRAME WORK

# Appendix A. System Specifications

| | Inch | Metric |
|---|---|---|
| **Space and weight** | | |
| Floor area (doors open) | 88 x 60 in. | (2032 x 2159 mm) |
| Floor area (doors closed) | 62 x 60 in. | (1626 x 1626 mm) |
| Height | 90 in. | (2286 mm) max. |
| Weight (with control) | 2920 lbs. | (1327 kg) |
| Shipping weight | 3310 lbs. | (1503 kg) |
| **Power** | | |
| Electrical supply-60HZ 3-phase | 208/230V/460V | |
| Main power breaker | 25a/15a per phase | |
| Electric rating | 6kVA | |
| **Color** | | |
| Standard | Gray | |

**NOTE:** Specifications subject to change without notice

# Appendix B. Static Sensitive Equipment

## B.1 STATIC SENSITIVE MATERIALS

This is to notify the appropriate personnel of the potential damage static electricity can cause to delicate electronic components and to outline guidelines to be followed when handling these electric components or assemblies.

Static damage of components by operating personnel is becoming a significant problem plaguing the electronics industry. Technological advances in IC manufacture make possible devices with greater circuit densities, higher unit performance and quite often, higher static susceptibility. Fortunately, the problems associated with static charges in the electronics environment can be controlled.

The following are some general guidelines to follow during assembly or handling of static sensitive devices or assemblies.

## B.2 GENERAL GUIDELINES

1. Since August, 1981, all printed circuit boards, or assemblies containing static sensitive devices have been **IDENTIFIED** by this label.
2. All assembly operations involving static sensitive devices must be performed at a specially grounded work station.
3. The technician must be grounded by use of the wrist strap when working at this station.
4. All electrical assembly equipment, such as soldering iron, should be grounded.
5. Avoid handling static sensitive devices except when absolutely necessary.
6. Under no circumstances should the static sensitive devices or assemblies containing static sensitive devices be allowed to come in direct contact with plastics (polyethylene bags, styrofoam, styrene boxes, plexiglass, etc.).

It is necessary for all field personnel to follow proper static prevention procedures when servicing Bridgeport equipment containing static sensitive assemblies. The following is a recommended procedure to follow when removing/replacing a printed circuit board containing devices from the card rack.

### B.2.1 Equipment Required

1. Portable static-free work station kit containing floor mat, grounding wire and wrist strap.
2. Protective connector shunt for printed circuit board, 3M Co. 5020.
3. Protective shipping/handling bag Part No. 3M Co. 2004.

### B.2.2 Procedure

1. Place a floor mat in front of the cabinet and connect ground wire to an appropriate earth ground. Check to make sure wrist strap is secure.
2. Stand on the mat and place a wrist strap on your wrist.
3. Carefully remove the printed circuit board from the unit.
4. Place the PC board in a protective shipping/ handling bag.

## B.3 VENDOR INFORMATION FOR STATIC PROTECTION EQUIPMENT

1. Work station kits.
   a. 3M portable field service kit - 8005 (Recommended for light duty).
   b. 3M Velostat floor mat - 1864
      3M static control Wrist strap - 2064
      (Recommended for heavy use).
2. Velostat PC board edge protector - 5200
3. Velostat shipping/handling PC board protective bag - 204

All equipment available from:
3M Static Control System
223-2 Southwest 3M Center
St. Paul, MN 55101
(612) 733-9420

# NOTES